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DEVELOPMENT OF INSTRUCTIONAL STRATEGIES FOR PTTI'S WITH SPECIAL REFERENCE TO EVS (SCIENCE) AND MATHEMATICS AT PRIMARY LEVEL OF WEST BENGAL

213/Gift

AN ACADEMIC REPORT

Jaydip Mandal
O.N. Singh
Programme Coordinators

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REGIONAL INSTITUTE OF EDUCATION
(National Council of Educational Research and Training)
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FOREWORD

The report presents the outcome of the academic initiative taken by my colleagues – Dr. J. Mandal and Dr. O.N. Singh of the Department of Education in Science and Mathematics. It depicts various instructional strategies for transacting EVS (Science) and Mathematics at Primary stage. Keeping the professional needs of primary level teacher educators of West Bengal, the instructional strategies are formulated centering on living things - animals and plants, the universe, some physiological processes in the human body, magnetism etc. in the area of Science, while focusing on the concept of real numbers, subtraction, division etc. in Mathematics. Well, the task involved was performed through reflection and action in workshop settings involving experts and teacher educators. The group formulated the various strategies in tune with science and mathematics syllabi of the Primary Board of West Bengal.

I appreciate the efforts of the experts - both internal and external - in generating the various strategies outlined in this report and hope that these ideas will be useful for teacher educators, and teachers as well.

M.A. Khader
Principal

Acknowledgements

We sincerely express our deep sense of gratitude to Prof. M.A. Khader, Principal of the Institute for his academic inputs, administrative support and constant inspiration in the preparation of the final manuscript.

Our grateful thanks are due to Prof. M.P. Sinha, Head, DESM and Dean of Instruction, RIE, Bhubaneswar for his academic inputs, keen interest and sustained cooperation throughout the programme.

We wish to express our gratitude to Prof. D. Lahiry retired Professor of NCERT, Dr. K.K. Chakraborty, retired Reader in Mathematics, RIE, Bhubaneswar and Prof. P.K. Durani, Prof. in Botany, DESM, RIE, Bhubaneswar, for sharing their rich experiences with the participants, reviewing the draft manuscripts and helping in the preparations of the final manuscript and making the programme a grand success.

We wish to express our grateful appreciation of the work done by Dr. (Mrs.) N.T. Chhotray, Dr. D.G. Rao, Dr. P.C. Agarwal, RIE, Bhubaneswar, Dr. A.K. Chatterjee and Dr. K.K. Dey of DHT college, Kolkata and participants of PTTI's of West Bengal. Hearty thanks are due to Directorate of School Education, West Bengal, Principal, DHT College, Kolkata, President & Secretary, WBBPE, and Director of SCERT, Kolkata for their kind help in deputing the participants and extending active support in conducting the Phase II of the programme at SCERT, Kolkata.

Sincere thanks are also due to DEE and accounts personnel of our Institute for their support in conducting the programme.

Last but not the least, we express our sincere thanks to Acharya Associates, Acharya Vihar, Bhubaneswar for typing out the report meticulously within short span of time.

Jaydip Mandal
O.N. Singh
Programme Coordinators

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INTRODUCTION

The emphasis has been placed on sharing practices, ideas, research and strategies to address common concerns in primary school science and mathematics education while acknowledging, honouring and incorporating differences in approaches based on geography, history, culture and/or language.

Noting the trend of curricula in our country emphasizing rote memorization of the facts of science, examples need to be provided of "hands on" approaches to teaching that had been developed and implemented in diverse regions of the world.

Now the challenge we face to make new instructional strategies for science and mathematics available to teachers in primary schools in impoverished areas of India. Our major concern is in making teachers more confident, comfortable and knowledgeable about the content they were expected to provide to children. There is a need to provide not only training but also emphasis is placed on hands on, integrative approaches to science teaching based on locally available material and locally meaningful themes.

The challenge for India, stems from the need to provide appropriate instructional preparation and professional development for a large number of teacher, geographically dispersed over great distance, in ways that are educationally sound. Goals for primary school education in science and mathematics extended beyond cognitive and skills development to include social, cultural and moral development. There was universal recognition to include social, cultural and moral development. There was universal recognition of the value of active learning and hands on approaches to teaching science and mathematics.

Beyond the key issue of universal access to education for girls and boys, there were concerns about mechanistic (rote) approaches to teaching and learning; learning experiences not connected to local situations; and inadequate participation of the science community in efforts to improve science and mathematics education.

Now what kind of programme is required to prepare teachers who can teach a new curriculum using more active methods? Subjects taught at the primary level were mathematics and environment related activities. Environment then becomes the basis for teaching other disciplines including science. At upper primary science is taught as an separate subject organised around five areas of study: (1) The living

world, (2) The physical world, (3) The material world, (4) Earth and the Universe, (5) The world of Technology. The goals for science necessarily were directed towards providing students basic education needed to manage their lives and their health.

The curricular needs regarding Science and Mathematics (EVS II) at Primary level, though, are taken care of broadly in the syllabi and textbook, there exists information gap with reference to knowledge, understanding, and application abilities. The unique position of science as a subject in the curriculum necessitates periodic introspection and development of necessary instructional contrivances to mitigate the problems. Teachers find difficulties in transaction due to lack of enrichment materials and appropriate strategies. The present programme was felt need by the State of West Bengal for the development of instructional strategies.

The objective was to develop instructional materials emphasizing different strategies on the identified topics in EVS II (Science) and Mathematics.

The methodology includes (i) critical analysis of EVS II science and mathematics textbooks of West Bengal and identification of thrust areas with reference to major concepts and minor concepts.

ii) To develop enrichment materials and instructional strategies on concepts and subconcepts.

In Phase I of the programme held on Oct.1-4, 2002 at RIE, Bhubaneswar, six internal resource persons analysed prescribed Science (EVS II) and Mathematics textbooks of W.B.B.P.E. and major and minor concepts were identified and suggested suitable instructional strategies to be followed by the teachers during transaction in the classroom.

In Phase II of the programme which was held at SCERT, Kolkata from Nov. 25-29, 2002, a brief report was presented at valediction on 29th Nov. 2002 as:

It was my pound privilege to present the brief valedictory report about the programme and the work done during the 5 days development programme entitled "Development of instructional strategies for PTTI's with special reference to EVS II (Science) and Mathematics at Primary level of West Bengal". This programme was as request programme from W.B. Government which was taken as a challenge

by our Institute and successfully completed with the kind efforts of our Principal who took a personal initiative to overcome the various initial hurdles in respect of finalisation of venue in particular. I should express my gratitude to Director, SCERT, West Bengal, his staff, research scholars and the administrative staff of the institute who left no stone unturned to see the materializing of the programme and ensuring the full participation of the resource persons from PTTI's in West Bengal. A total of thirty seven participants participated in the programme which included 16 resource persons from different PTTI's of West Bengal, 2 resource persons from David Hare Training College and 5 faculty members from NCERT and RIE in addition to resource support provided by Director and Assistant Prof. and six research scholars from SCERT. The inaugural session started with welcome address by Prof. P.K. Durani, RIE, Bhubaneswar. This programme was inaugurated by Prof. Dilip Kumar Chakrabarty, Principal, David Hare Training College, Kolkata. In his inaugural address, Prof. Chakraborty, commended the efforts of NCERT, New Delhi and RIE, Bhubaneswar in improving the quality of education in general and universalisation of quality elementary education in particular in the country. He further appreciated that the programme of this kind will have far reaching effects in improving the standards of Primary Education in West Bengal. The inaugural session was also addressed by Dr. R.N. Dey, Director, SCERT, Kolkata, Dr. Swapan Kumar Sarkar, Secretary, WBBPE, Prof. D. Lahiry, retired Professor of NCERT, New Delhi, Dr. K.K. Chakraborty, retired Reader, RIE, Bhubaneswar all of whom explained the importance of programmes of this type for quality education to school children in the country. The inaugural session came to and end with vote of thanks by Dr. Jaydip Mandal, Programme coordinator and Sr. Lecturer, RIE, Bhubaneswar. This was followed by formation of several groups and the group works started separately in mathematics and EVS II (Science). It is my great pleasure to keep on record the sincerity of all the resource persons who put in their efforts and worked sometimes overtime following a preset format for the schedule of work to my entire satisfaction. The major topics on which the teaching strategies were developed, included Living things-animals and plants, The Universe, Magnetism, Electricity, Some physiological processes in the human body etc. in EVS (II) science and Concept of real numbers, addition, subtraction, division etc covering textbooks of Class III, IV and V followed in primary schools of West Bengal.

I am highly indebted to our ever dynamic Principal, Prof. M.A. Khader, who has been associated with this programme right from the inception to its logical conclusion. His expert discourse on pedagogical rationale on strategies for

preservice and inservice teachers was highly illuminating and thought provoking which was evident by the lively discussion that followed one and a half hour lecture.

I thank our Principal Prof. M.A. Khader, Dr. R.N. Dey, Director, SCERT, Dr. Sujit Mukherjee, Asst. Professor, SCERT, Prof. D. Lahiry, Dr. K.K Chakraborty, Dr. Dilip K. Chakaravorty, Dr. Swapan K. Sarkar, Prof. P.K. Durani and Dr. O.N. Singh for their unwavering help for the success of this programme.

I am really thankful to all the participants who have come from different corner of the state and putting their soul and mind to make this programme successful. Really at times we have tested their patience but fruition of their patience will be ever sweet.

The Phase III of the programme was organised at RIE, Bhubaneswar from March 24-28, 2003 to review and validate the draft report on enrichment materials and teaching strategies developed in Phase II of the programme. A total of 8 resource persons including two external resource persons and six internal resource persons participated in this programme. The draft manuscript was reviewed and refined and valuable suggestions were given for improvement of the final manuscript.

I express my deep sense of gratitude to Prof. M.A. Khader, Principal, RIE for his constant inspiration and administrative support. My heartfelt grateful thanks are due to Prof. M.P. Sinha, Head, DESM and Dean of Instruction for his kind support and constant inspiration.

I am grateful to Prof. D. Lahiry, retired Professor of NCERT, New Delhi, Dr. K.K. Chakraborty, retired Reader, RIE, Bhubaneswar and Prof. P.K. Durani, Professor in Botany, RIE, Bhubaneswar for thoroughly reviewing the draft manuscripts and invaluable suggestions for the improvement of the final manuscripts.

I wish to express my grateful appreciation to internal resource persons for the work done for the improvement of the final manuscript.

To improve the teaching status of science in different Teachers' Training Institute this Part of the module must focus on the objectives of teaching in P.T.T.I.'s. Once the objectives are identified the teaching strategies of entire curriculum will be very clear to the teacher educator/teacher trainees.

Objectives	Suggested Teaching Strategies
1. To make the teacher trainees aware of syllabus and the objectives of EVS II (Science) and Mathematics in primary classes	1. Teacher educators should ask each trainee to collect the syllabus of EVS II (Science) and Mathematics to review the same thoroughly. The teacher/educator should discuss the objectives of teaching EVS (Science) and Mathematics in primary school.
2. To develop confidence in each teacher trainee by giving sufficient content knowledge of the subject.	2. It is the duty of teacher educators to refresh the subject/content knowledge of the trainees. The teacher educator will read the chapter properly and clarify all the doubts that arise. In case trainees do not find any difficulty in understanding the specific content or do not have any specific question to be answered, teacher educators may mention some exceptional cases and critical examples, to enrich the content knowledge of the teacher trainees.
3. To enable the teacher trainees know about different aspects of teaching EVS II (Science) and Mathematics in primary classes.	3. Teacher educator should discuss various methodologies of teaching science (e.g. observation method, demonstration method, Heuristic method, project method etc.) in primary classes with suitable examples. The trainees should be made aware of the fact that no specific method of teaching of science and mathematics is self- sufficient. The teacher trainees may choose any method or combination of methods which they think as the most suitable for teaching a specific concept.

Objectives	Suggested Teaching Strategies
4. To enable the teacher trainees to develop the skill of performing different practical works or scientific activities.	4. The trainees may not be able to perform the practical work in the classroom satisfactorily in front of the students unless the trainee himself has tried it first during the course of his/her training in the Training Institute. It is therefore, very essential to test the workability of the practical work before demonstrating it to the students. The trainees may be divided into several groups depending on the number of trainees. Each group may be given one or two activities like preparation of charts, model making, collection of different specimens from nature and preserving them etc. Training thus imparted can be transacted with ease to the pupils in the class. The trainees may be encouraged to do different experiments and exhibit them in exhibitions conducted by teacher educators in Training Institute. They may also be given some scientific topics to discuss in groups which will be evaluated by the teacher educators.
5. To develop skills in the writing of lesson plan (daily and yearly) and also to develop the skills in the use of teaching-learning materials, use of blackboard, skill of questioning, skill of application of different methods of teaching in primary classes.	5. The necessity of preparing lesson plans must be discussed clearly by the teacher educators. The most important aspect of lesson planning is that the trainees should be given clear idea of yearly lesson plans so that they can select the portion of each topic to be taught in the class properly.

Objectives	Suggested Teaching Strategies
	The teacher educators will make the trainees to write lesson plans daily, collect or prepare teaching-learning material and practice teaching in schools. Their teaching strategy is to be supervised by the teacher educators. **Comments :** Every teacher educator should write his/her own yearly planning of teaching which may be approved by the Head of the Institution.

EVALUATION:

For evaluating the teacher trainees as well as pupils in the primary schools evaluation on remedial teaching is necessary. For the purpose of evaluation the teacher educator should keep in mind certain points while selecting an evaluation device. Firstly, the teacher educator will remember that objectives to be evaluated are more important than the kind of device/instrument to be used. For example: Evaluation of knowledge or identification might require an objective test. Second, good test questions are difficult and time consuming to prepare, and they should be constructed with much thought and care. Third, all tests contain an element of objectivity, some tests more than others. The following devices/instruments of evaluation can be followed:

1. Periodical Testing
2. Comprehensive Evaluation
3. Asking questions of true-false, matching items / Multiple-choice / Recall or memorization / Error correction / Completion items/recitation (question and answer method)
4. In the form of quiz / debate/crossword puzzle /puzzle wheel
6. Collection of pictures/making collage etc.
7. Making models and charts/ science magazine
8. Silent sitting / Role playing
9. By playway method
10. Oral discussion is more effective in appraising the children's knowledge of science content, in determining scientific attitudes and in diagnosing the children's strengths and weakness.
11. Simple objective tests/easy questions/problem situation questions/thought questions
12. Checklists and rating scales to evaluate both individual and group behaviour.

SCIENCE SECTION

LIVING AND NON-LIVING THINGS

Major concept(s)

All the things on this earth are either living or non-living

Minor concept(s)

1.a) Living things differs from non-living things in several characters

b) Living things grow

c) Living things respire

d) Living things need energy in the form of food

e) Living things move

f) Living things respond to external stimuli

g) Living things reproduce

2. Living things include plants and animals

Suggested Teaching Strategies

The teacher educator will guide the trainees/pupils to minutely observe the environment around them and make a list of living things around them. They will also make another list of non-living things found around the living things. They will collect pictures of different living things and paste them in their "Nature Study Book".

Teacher trainees/pupils will study various characters of living things and compare it with the characters of non-living things and tabulate their findings.

Characteristics of

Sl.No.	Living things	Non-living things
1.		
2.		
3.		
4.		

Teacher educator should explain that moving fan, dancing doll, motor car and similar non-living things can't be considered as living things even if they appear moving. Teacher trainee may be guided to prepare a chart as follows:

3. All living things depend on environment for their existence

Living things	Non-living things
1. Crow	1. Do not grow
2. Reproduce	2. Do not reproduce
3. Move or exhibit locomotion	3. Exhibit no movement or locomotion
4. Respond to stimuli	4. Do not respond to stimuli
5. Respire	5. Do not respire
6. Require nutrition	6. Don't need nutrition
7. Have mechanism for excretion	7. Do not excrete

Several examples can be cited and activity demonstrated which can amply distinguish living things from non-living things. Teacher trainees/ pupils will observe the living things in their environment and list them under the headings Animals and Plants.

Livings things

Animals	Plants
1.	1.
2.	2.
3.	3.
4.	4.

Teacher trainees/pupils will observe living things both plants and animals and list the materials like food, water, air etc. which are essential for their existence.

LIVING THINGS — ANIMALS AND PLANTS

Major concept(s)

Living things have distinct life processes

Minor concept(s)

- All living things grow
- All living things take in food that undergo digestion for nourishment
- All living things have assimilation i.e. changing food into protoplasm
- All living things have respiratory activity as energy freeing process
- All living things have motion
- All living things are able to reproduce living things of the same kind

Suggested Teaching Strategies

1. At first the teacher educator should ask the teacher-trainees to identify the major and minor concept on the topic (Living World Animals and Plants)

2. To begin the lesson the trainees should discuss about the differences between living and non living as a recall of the previous chapter before proceeding to teach the topic properly. The examples used in the test like the movement of electric fans, dancing doll, running train should be discussed by the teacher educators. This will help the trainees to explain the concept(s) more authentically and meaningfully.

3. The teacher trainees will be divided into several groups. Each group will prepare picture charts following cut and paste techniques using old newspapers, magazines etc.

4. Each group will be assigned a job to prepare a chart/poster highlighting one specific character/minor concept of a living organism as identified earlier.

5. Teacher educators should help trainees to demonstrate different experiments explaining the characters of living things:

Minor concept(s)

- All living things have definite span of life
- After death all living things are changed into non-living things i.e. elements and compounds
- Mostly living things exhibit circulation i.e. movement of digested food
- All living things are made up of one or more cells

Suggested Teaching Strategies

(a) Demonstrate how a snail on a plate changes its path when some salt is sprinkled on the plate.

(b) Demonstrate how the leaves of a lajwanti (*Mimosa pudica*) plant droop in response to gently stroke or slight touch to its leaves and will not regain its original shape for several hours

6. Pupils activity:

Take a Petri-dish. Place a piece of moist cloth or wet filter paper. Spread a few soaked pea/gram/bean seeds on the wet cloth/filter paper. Cover the disk and keep it one corner of the room for a few days. Observe the seeds germinating in the petridish. Note that a plant grows taller at its tip, not of the bottom. When the plants are about 5 centimeters (2 inch) high mark he stems with nail polish 2½ centimeters (1 inch) from the soil. Check the height of the marks periodically. Keep a record of growing seedlings after every 3-4 days. Ask the students to draw the various stages of growth.

7. Teacher trainee/pupil activity

Trainees may set up an aquarium to show how the living world depends on non-living world and how living and non-living things exist together.

Take a clean glass aquarium or wide mouthed jar, pour washed sand in it. Then fill ¾th of the container with water (clean pond water or stored tap waters, leave it undisturbed for few days. Then introduce *Hydrilla*, *Valisneria* (aquatic plants) and place them in the sand. Introduce a few fishes like goldfish, catfish or any tropical fish in the aquarium.

Suggested Teaching Strategies

The aquarium has a perforated cover that permits free flow of air. Place it in a airy place and avoid continuous direct sunlight.

8. Teacher-educator will discuss about the nature's corner and trainees should build up natures corner in their classroom by placing several living and non-living materials (e.g. feather, beak, nest, left over bee-hive, termite mount, ant, butterfly, mosquito, snail, earthworm etc.) with short description about the particular specimen pasted on it.

Major concept(s)

Living things are classified as animals and plants (animal kingdom and plant kingdom)

Minor concept(s)

- Animals are broadly divided into two groups : Vertebrates and Invertebrates
- Animals with backbones are vertebrates
- Animals without backbones are called invertebrates

To cover the major ideas the teacher educator will follow the strategies given below:

i) The teacher educator should focus only on the living things while classifying animals and plants.

ii) Teacher educators should ask a few questions pertaining to the characteristic of animals and plants or to write few sentences describing their characteristics. The cells of members of the animal kingdom are slightly different from the cells of the members of the plant kingdom.

i) Animal cells do not have chlorophyll

ii) All animal cells do not have a cell wall, made of cellulose around them

iii) Teacher educator will explain the special characters common to both plants and animals. They should also explain the exceptional cases of plants and animals with controversial characters e.g.

Euglena sp. – Is it a plant or animal?

Volvox sp. - Is it a plant or animal?

Suggested Teaching Strategies

iv) Teacher educator should discuss in detail about the classification of animals as Vertebrate and Invertebrate. Vertebrates include five important classes as: (a) fish (b) amphibians, (c) reptiles (d) birds and (e) mammals

v) Teacher-educator provides more information regarding Vertebrate and describe in a way so that the concept is cleared. For example: Animals having a backbone which replaced the notochord are called vertebrates. They have skeletons inside their bodies and two pairs of limbs attached to their body.

a) Teacher educator may discuss distinguishing features of the vertebrate classes. a) Fish: They are cold-blooded animals, possess bony skeletons and their bodies are covered with scales. They breathe by gills.

b) Amphibians are cold blooded animals, live both land and water. They develop lungs for breathing in later age and have a smooth skin without scale (e.g. frog, toad, salamander)

c) Reptiles are cold blooded animals, breathe by lungs and usually have a rough, dry, thick, scaly skin (e.g. snake, lizard, crocodile and turtle). Teacher educator should provide information about poisonous snakes. Trainee/ pupils should learn and well aware of kinds of poisonous snakes, if any in their region. Instruct the trainees to collect pictures of poisonous snakes and learn to recognise them on sight. Pupils are to be shown pictures and help them to recognise poisonous snakes. They are to learn where these snakes are most likely to be found and caution pupils about these places. They should find out what proper first-aid treatment would be for bites from these snakes.

Suggested Teaching Strategies

d) Birds are warm-blooded animals, breathe by lungs, bodies are covered with feathers, legs scaly and skeleton light, hollow and streamlined for flying.

e) Mammals are warm-blooded animals and breathe by lungs. They usually give birth to living young and suckle their young with milk from mammary glands. All mammals have hair on their bodies. All mammals have seven neckbones.

Teacher educator should cite some interesting examples: i.e. a) Bat can fly - is it a bird ? (b) Turtles and crocodiles live both in water and land, are they amphibians ?

Minor concept(s)

- Insects make up the largest class (Insecta) in the animal kingdom

vi) Teacher educator may explain that invertebrates do not have any coherent grouping. Invertebrates include : a) Poriferans (e.g. sponges), b) Coelenterates (e.g. jelly fish, hydra, coral etc.), c) Platyhelminths (e.g. tape worm), d) Annelids (e.g. earthworm, leech etc.), e) Echinoderms (e.g. starfish), f) Mollusks (e.g. oyster, snail, octopus, g) Arthropods (e.g. crab, lobstar, spider, millipede and all insects). Teacher educator will explain that all insects form a special class of phylum Anthropoda called Insecta. Insects have an outside skeleton made of a tough material called chitin. Their legs and other parts attached to the body, all of which are called appendages that are jointed and can bend. They have bilateral symmetry. Besides, insects have three separate body regions: the head, thorax and abdomen. They have one pair of feelers, called antennae, attached to their head. They have three pairs of legs attached to the thorax and one or two pairs of wings in most insects, attached to the thorax. Most adult insects have both simple eyes (just one lens) and compound eyes made of many single lenses.

Minor concept(s)	Suggested Teaching Strategies
Some insects are helpful and some are harmful	Teacher educator may give common examples which provoke interest among trainees/pupils. Trainees/pupils need to be well aware of those insects which are helpful to human beings in many ways (i) Many insects such as bees, wasps, butterflies, moths, beetles, bugs and certain kinds of flies play important role in pollination of a variety of plants. (2) bees produce honey and beeswax, (3) the silk moth gives us silk, (4) the lac insect gives us shellac, (5) some insects especially dragonfly eats harmful insects, (6) some insects like the carrion beetle are scavengers feeding on the dead bodies of animals. The teacher educator may also highlight the harmful nature of insects: (1) The grasshopper and boll weevil destroy grain crops, fruits and vegetables, (2) some insects such as termite destroy wooden furnitures and buildings, (3) certain moths destroy clothes and carpets (4) some insects like the mosquito, louse and fly carry disease germs to man and animals. These insects as well as bed bug are parasites on man and pet animals, (5) some insects especially cockroach and fly contaminate food (6) some insects like wasp, bee, and mosquito annoy man and animals by stinging and biting. **Teacher trainees/pupils activity** Teacher trainees are to develop skill of listing helpful and harmful insects commonly seen in their surroundings. Teacher educator may help the trainees to examine the different. Insects under a magnifying glass or the low power of a microscope. Describe and compare, wherever possible their wings, antennae, mouth parts and legs. Teacher educator may discuss about food habits of insects and help the trainees to decide whether the collected insects are helpful or harmful. Teacher eudcators should focus on interesting aspects like : How does a spider differ from an ant although they look similarly ? Point out that spider has four pairs of legs and ant has three pairs of legs. Whey can't all insects construct a web? Why the spider does not get entangled in its own web ?

Suggested Teaching Strategies

Trainees should have the knowledge that mollusks have soft, fleshy bodies with no segments. Most mollusks have the characteristic protective shell made of lime. The snail, oyster, clam and octopus are the members of the phyllum Mollusks.

Teacher trainees/pupils activity

Trainees can collect land snails which are often found early in the morning feeding on plants in the garden. They can be kept in a glass jars containing damp garden soil. Keep the mouth of the glass jar covered with screw top already perforated by a nail. Keep the snail well supplied with soft, green leaves. Teacher educator may help the trainees to observe how the snails foot leaves a trail of slime, along which it travels. See how the snail quickly shreds the leaves with its tongue. Look for the eyes at the ends of the larger pair of feelers. Touch the feeler gently with a pencil, see how it retracts. Teacher educator may ask trainees to collect a variety of empty/live shells from nearby sea coast and point out that nature has bountiful of Mollusks.

Minor concept(s)

Annelids are the worm with round bodies

Teacher trainees/pupils will learn that annelids are worms with round bodies that are divided into rings or body divisions, called segments. Teacher educator may explain that annelids have many well-developed organ systems, which include a digestive system, a circulatory system, an excretory system, and a nervous system. Examples: earthworm, leech etc.

Teacher trainee/pupil activity

Teacher trainees may collect earthworms from a rice garden soil or they may have to wait until after a heavy rain, when the worms come to the surface at night. Keep the worms in boxes containing rich garden soil and cover the box with a damp piece of thick cloth.

Suggested Teaching Strategies

Place an earthworm on a damp paper towel and see how it crawls by lengthening and then contracting its body. Find the head of the earthworm, touch the head and observe how the worm contracts the front part of its body, it may even crawl backward. With a magnifying glass, observe setae or bristle feet on the underside of the earthworm. Also observe, how the worm pulls its head away from the bright light when exposed to a flashlight on the worm's head in a dark room. Teacher educator may also explain usefulness of this worm to the soil structure for agricultural operation/crop yield.

vii) Preparation of "Animal Book"

Teacher trainees activity

Trainees should make a chart showing the classification of animals. An album illustrating different characteristics of vertebrate and invertebrate may be prepared by the trainees. Teacher trainees may be guided to prepare the 'Animal Book' by collecting pictures of different animals from different magazines and pasting these in systematically.

viii) An educational excursion may be conducted by the teacher educator to a museum, science laboratories in different colleges and universities to observe the display of preserved specimen of butterflies, leach, earthworm, bivalve mollusks showing pearl inside it, shark, snake, lizard etc.

ix) Teacher trainees/pupil may visit zoo with their teacher educator to observe different animals, their characteristics, habitat and feeding habit. During the course of such excursions the teacher educator should evaluate of trainees for their leadership, capacity to maintain the discipline and there concern for surrounding and environment.

	Suggested Teaching Strategies
	x) Teacher Trainees should arrange an exhibition in their institute showing models of animals as observed by them in the zoo's or museums and laboratories. Alternatively trainees may perform activity (Zoo formation) with the help of the pupils in their primary schools.
	xi) Teacher educator may advise the trainees/ pupils to read about and report on conservation of fish, birds, animals and economically important medicinal plants. Teacher educator will aware them what kinds of animals are protected by law and facilitate to obtain a copy of the game laws for their area or state from state Government forest or zoo authorities. Trainees/pupils may be shown pictures or films on the establishment of fish hatcheries, bird sanctuaries and game preserves.
Major concpet(s) Plants grow in various habitats	i) At first teacher educator may have to describe elaborately different types of plants growing in natural habitats.
Minor concept(s) i) Some plants grow on land ii) Growth of plants requires necessary conditions iii) Some plants grow in water	ii) Teacher educator may provide more informations about every type of plant requiring specific environmental conditions for its growth e.g. air, water, temperature, light, soil, chemicals in the soil available and climatic condition etc. These conditions are very different from place to place and regions to regions. Therefore, different kinds of plants are found in different regions. iii) Trainees should know that water plants also known as hydrophytes are of different types depending upon whether the plant grows in freshwater or marine water, in running water or still water or are rooted in mud.

	Suggested Teaching Strategies
iv) Some plants grow in moist places	iv) Teacher educator will divide trainees into 3 groups, 1st group - will collect land plants, 2nd will collect water plants (hydrophytes) and 3rd group will collect plants growing in moist shady places, e.g. Ferns. This activity should be done through project method. v) Pupils Activity - Field trip: Teacher trainee may take the pupils to a nearby pond, Ask them to line up and stand around the pond. Ask them to make note of all the plants in the pond. They may find some big plants e.g. lotus, water lilly, water nut and some are small freely floating in the pond like *Pistia, Salvinia* and others are sumberged like *Hydrilla Vallisnaria* etc.
Major concept(s) Plants are divided into different groups on the basis of characters.	i) Teacher educator may explain the green material called "Chlorophyll" in leaf. Only green plants are able to manufacture their own food. It may be explained that chlorophyll is a very complex substance consisting of C,H,O,N and Mg elements. This pigment imparts green color to the leaf and makes it possible to make food for the plant.
Minor concept(s) i) Mostly plants are green and some are non-green.	ii) Teacher educator may explain the nature of non-green plants i.e. fungi which grow on decaying wood, moist bread, cowdung, leather, dead plants and animals or food products of plants and animals. Fungi do not have chlorophyll and can not made their own food. Examples : molds, yeasts, mushrooms etc.
ii) Flowering plants are called phanerogams while non-flowering plants are called cryptogams.	Teacher educator may briefly discuss the classification of plants as flowering and non-flowering groups. Classification of non-flowering groups into algae, fungi mosses and ferns should be property clarified with their respective characteristics.

Suggested Teaching Strategies

i) Algae : Teacher educator should tell the trainees that algae are now grouped under the Protista kingdom. Algae are able to make their own food by photosynthesis, just as plants on land do because cells of algae contain chlorophyll. Besides, green color chlorophyll, algae also have other pigments such as phycocyanin, phycoerythrin, fucoxanthin that hide the green colour. Teacher educator may highlight the importance of microscopic or macroscopic algae found in freshwater, salt water, and even on land. Trainees should know that algae are the chief sources of food for many animals that live in the water and also used as food for human beings. They give off oxygen which water animals need to live. Algae are the source of material 'agar-agar' used for growing bacteria in laboratory and hospital.

Teacher trainee/pupil activity

Teacher educator may arrange a field trip to acquint the trainees with the algae growing profusely in the water drainage, canals, ponds, lakes, sea ad oceans. Taking the trainees to a museum, college or universities help them to observe various preserved algae. Teacher educator may discuss the importance of algae as a food chain in water bodies, sources of food, chemicals and other raw materials like 'agar-agar':

ii) Fungi : These are the members of the protista kingdom. They do not have chlorophyll and can not make their own food. Hyphae of fungi usually white or gray but many fungi have red, orange, yellow, blue, green or black pigments that give the fungi a special color. Teacher educator may also brief the trainees the nature of fungi. Parasitic fungi get their food from living plants and animals whereas other fungi i.e. saprophytic fungi get

their food from dead plants and animals, or from food products made from plants and animals. Nearly all fungi are aerobic being able to use the free oxygen in the air to live. Trainees should acquire knowledge about mushrooms cultivation. Mushrooms are the saprophytic, macroscopic largest fungi. Trainees to be well aware of poisonous mushrooms while some mushrooms are good to eat. Some edible cultivated mushrooms are *Agaricus bisporus, Pleurotus sajor-caju* and *Volvariella volvacea* which can be eaten after cooking. Mushrooms are harvested when they are young and before their spores have ripened.

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Library

Teacher trainees /pupils activity : 1 Teacher educator will help the trainees how to grow molds. Instruct the trainees/pupils to rub a piece of bread across a dusty surface and then moisten the bread with water. Keep the bread in a covered Petridish and leave it in a warm, dark place. Trainees/pupils will observe a white, cotton like mold after a few days. They may also note the black spots, which are spores of *Rizopus stolonifer* or *Mucor* sp. Trainees/pupils can learn that molds which grow on cheese, jam or wet orange kept in a closed container placed in a warm, dark place for few days. Teacher educator will have to caution the trainees that one should not touch spores with fingers or inhale them, failing they are likely to contract skin disease or may cause several complications.

Teacher trainee/ pupil activity : 2 Teacher educator will have to brief the trainees about season of growing mushrooms, place of availability and importance of mushrooms as a source of human food because of the rich percentage of proteins, essential aminoacids, important ratio of sodium and potassium, lack of starch, devoid of sucrose and rich

medicinal properties. Trainees are instructed to collect full grown mushrooms and examine the stalk, cap and gills. Trainees are to be told that mushrooms are eaten after cooking. Teacher educators have to caution trainees/pupils of some poisonous mushrooms while collecting from wild palaces needs to be discouraged.

iii) Mosses : Mosses are the members of the large division of plants called Bryophyta. Most of the mosses live on land. They are small plants, possession chlorophyll and can make their own food. Mosses have simple leaves but no true roots and stems, though they do have root like and stem like parts. They do not produce flowers, fruits and seeds. Teacher educator may give examples of mosses such as *Sphagnum* or peat moss and *Funaria*.

iv) Ferns: Teacher educator will distinguish between bryophytes and tracheophytes. Ferns are the members of tracheophytes that have a continuous system of tubes running through their roots, stems

and leaves. They all have true roots, stems and leaves but they do not produce flowers, fruits and seeds. They are mostly land plants and grow in cool, damp, shaded places but some grow in the cracks of rocks in the fields and open woods. Ferns possess chlorophyll, colored green and capable of making their own food. Teacher educator may help the trainees locating ferns, identifying and naming ferns (eg. *Dryopteris*)

	Suggested Teaching Strategies
Minor concept(s) Flowering plants are divided into three broad groups: herbs, shrubs and trees	Teacher educator may have to distinguish between herbs, shrubs and trees. A herbaceous plant is any small plant with a soft stem which may or may not be green. Soft stems of herbaceous plants last for only one growing season and then dies to the ground. Flowers, common weeds, garden vegetables and the cereal grains are all herbaceous plants. Shrubs are usually medium sized bushy with a hard stem (e.g. shrubby basil *Ocimum gratissimum*, Rangan (Ixora etc). Woody plants (trees) have a hard stem and are usually brown coloured. This hard stem does not die but continues to grow year after year as of shrubby woody plants. Wood plants have a stem both longer and wider each year. Teacher educator may give the examples of trees such as neem, mango etc. Trainees/pupils should know that all trees, shrubs and herbs (crop plants, vegetables, flowers, weeds, grasses) are seed plants which produce flowers, fruits and seeds. These seed plants grow in soil and in freshwater. **Teacher trainees/pupils activity** Have the trainees/pupils collect actual herbaceous shrubby and woody plants (trees). Teacher educator may arrange field trip and help them how to collect these plants, which part to collect and how to preserve in the field situation. Instruct them to compare the stems of these plants, note their special characteristics and make a list of similar and dissimilar characters.

Suggested Teaching Strategies

Characteristics

	Similar	Dissimilar
Herbs		
1.		
2.		
3.		
Shrubs		
1.		
2.		
3		
Trees		
1.		
2.		
3.		

Teacher activity : Teacher

Teacher trainees should prepare 'Pocket Board' illustrating non-flowering and flowering plants (herbs, shrubs and trees) by making small cards.

Suggested Teaching Strategies

Teacher trainee activity

Pupils can collect pictures of herbs, shrubs and trees from different magazines and paste them on a chart paper. The charts prepared by them can be used as teaching aids by the teachers as well. This activity increases enthusiasm among pupils to learn more about science.

Major concept(s)

All seed plants produce fruits

Minor concept(s)

i) Fruit is the ripened ovary of the flower

ii) Fruits contain seeds

Teacher trainees should understand that all seed plants produce flowers, fruits and seeds. Teacher educator may explain that after the ovule in the ovary has been fertilized, seeds form and the ovary becomes large. Trainees should define the fruit as the ripened ovary of the flower, with or without other parts of the flower. Fruit is the part of the plant that contains the seeds. They may explain that the word "fruit" not only means tree fruits, such as apple, pear, mango, coconut, orange, papaya and banana but also means the fruits of garden flowers, shrubs, flowering trees and cereal grains such as corn, oats, wheat and rice (i.e. ripened ovary from any flowering plants).

Teacher trainees /pupils activity :

Give a list of fruits to trainees/pupils : Instruct the trainees/pupils to tell you, when eating these fruits, they eat the whole fruit, just the fleshy part or just the seed. Classify the fruits as under :

Major concept(s)

All flowering plants (seed plants) reproduce through seeds

Minor Concept(s)

i) Seed is the fertilized ovule

ii) Seed has three parts

iii) Seeds store food in cotyledons

iv) Embryo becomes a new plant

v) Seeds need conditions to grow

vi) Stored food in seeds helps the young plant grow

vii) Seed germinates into a seedling

Suggested Teaching Strategies

Sl.No	Whole fruit	Fleshy part of fruit	Just seed
1.			
2.			
3.			

i-iv) Teacher educator may facilitate the trainees/pupils to understand that seed is a ripened ovule that has been fertilized by a grain of pollen. A seed is the part of a plant that gives rise a new plant of the same kind. Trainees will have to understand that all seeds have three parts : a seed coat, stored food and a tiny young plant, called the embryo.

Monocotyledon plants store their food in one seed leaf or cotyledon (e.g. corn, rice) when dicotyledon plants store their food in their two seed leaves (cotyledons) e.g. bean, pea.

Teacher educator may explain that the embryo has tiny roots, a stem and leaves that will become the new plant.

Pupils activity : 2

Teacher trainee may help the pupils to examine parts of a seed. Pupils are asked to soak pea in water overnight. Remove the seed coat and examine the two seed leaves (cotyledons). Pupils can observe the tiny embryo that is attached to one of the seed leaves, with the magnifying glass. This activity can be repeated using a kernel of corn where pupils observe only one cotyledon.

Suggested Teaching Strategies

(v-vii) Teacher educator will briefly discuss the conditions necessary for seeds to grow. Seeds need water that softens and swells the seed coat. They require optimum temperature ranges between 60 to 80 degrees Fahrenheit for best growth. Seeds need air to grow indicating looseness of soil helps better growth. They require medium or room to grow which means that they grow best when they are away from the plants that produced them.

Trainees must understand that seeds do not need sunlight when they first begin to grow but as soon as new plant grows leaves, it needs sunlight to make its own food. Teacher educator will explain that as long as the young plant depends upon the stored food to live i.e. for the formation of roots, stem and true leaves, it is called a seedling. The true leaves of the young plant then continue to supply food for the plant by photosynthesis

Teacher trainees/pupils activity : 3

Teacher educator may demonstrate the germination of seeds. Trainees may be asked to obtain seed (pea, bean etc.). Line a water tumbler with a piece of dark coloured blotter and stuff absorbent cotton, tight the tumbler to keep the blotter tight against the sides of the tumbler. Soak the pea/bean overnight and place on the cotton and a few of each between the blotter and the sides of the tumbler. Trainees must moisten the cotton and keep it moist ensuring that the blotter remains always moist. Keep the tumbler in a warm place, avoiding direct sunlight. Trainees/ pupils will observe each day and examine the way the seeds germinate. Allow all seeds to germinate well. Teacher educator may help the trainees to locate the various parts of embryo. This activity can be performed through project.

Suggested Teaching Strategies

Teacher trainees/pupils activity : 4

Teacher educator will demonstrate that seeds need optimum conditions to germinate. Trainees may prepare tumbler germinators described in activity 3. Firstly, place one tumbler containing pea/bean seeds in the dark and another in the light (not in direct sunlight). Teacher educators may point out that seeds will germinate just as well in the dark as in the

light. They will conclude that light is not necessary for germination or sprouting. But trainees must be well aware that once the seed has germinated and formed leaves, it needs light to grow.

Secondly, keep one tumbler with seeds watered regularly and refrain from giving the other tumbler with seeds any water at all. Trainees/pupils will observe that the seeds in the dry tumbler will not germinate.

Thirdly, cover one tumbler with seeds (pea, bean) tightly with plastic wrap and keep the other tumbler with seeds exposed to air. Trainees/pupils will find that the seeds in the 1st tumbler (covered) will not germinate due to absence of air (oxygen).

Fourthly, keep one tumbler with pea/bean seed in the refrigerator and another at room temperature. Trainees/pupils will observe that the seeds kept in the refrigerator will not germinate because the seeds need optimum temperature (warmth) to germinate.

Major concept(s)

Green plants can prepare their own food when animals cannot make their own food.

Minor concept(s)

i) Making of food takes place in the leaf of the plant

ii) Plants need sunlight, water and CO_2 to prepare sugar (glucose) in the green leaves

Suggested Teaching Strategies

Likewise, trainees/pupils may carry out activity to observe efficacy suitable room or medium (good earth or soil) for the seed to germinate by placing seed in different pots i.e. 1st with sand, 2nd with clay and 3rd with rich garden soil and subjecting them same temperature, water and air.

Trainees/pupil Activity : 5

Teacher trainees may be asked to collect as many different types of fruits and seed as they can for understanding the size, shape, structure, color and nature of different type of fruits and seeds.

i) Teacher educator may provide more information about photosynthesis. For this purpose energy flow from sun to green plants may be discussed elaborately. The leaves of plants contain green material chlorophyll when animals do not contain chlorophyll thereby unable to make their own food. Teacher educator may explain a few type of food chains to demonstrate that in all these the animals depend on plants directly or indirectly for their food requirements.

Teacher educator may explain the role of chlorophyll in photosynthesis. By using the energy of sunlight, chlorophyll helps the carbon dioxide and water to form sugar, called glucose, and a gas, called oxygen. This food making process in the plant is called photosynthesis. The leaf changes sugar (glucose) to starch or complex carbohydrates and some of the sugar to fats and proteins.

iii) The leaf changes sugar ($C_6H_{12}O_6$) into a variety of substances

Major concept(s)

Besides, food plant helps us in many other ways.

Minor concept(s)

i) Plants maintain balance of O_2 and CO_2 concentration in atmosphere

ii) Plants prevent erosion and flood

iii) Plant gives out excess water as water vapour to the air which helps to cool the atmosphere.

Suggested Teaching Strategies

ii) Pupils activity :

Pupils make a list of food that they take in their everyday food items and could link plants as the only living things which make their own food.

The Teacher educator should ask the trainees to cite examples highlighting the importance of plants and their contribution for human use. The examples cited may be in addition to those already provided in the text book. If the informations supplied by the teacher trainee seem to be inadequate the teacher educator will provide the additional information and cite several interesting examples to highlight the importance of plant.

i) Teacher educator may explain the contributions of green plants in maintenance of balance of oxygen gas and carbon dioxide in the atmosphere. Oxygen gas which is a waste product of photosynthesis is given off into the air through the stomata of the leaf in plants. Plants have been purifying air by assimilating carbon dioxide gas given off by factories, automobiles, industries and respiratory activity of all living beings. On the other hand plants and animals use oxygen in their energy-freeing process called respiration. Here, teacher educator will highlight that photosynthesis uses carbon dioxide from the air and gives off oxygen while respiration uses oxygen from the air and gives off carbon dioxide.

ii) Teacher educator may explain with the help of suitable experiments how the roots of plant can prevent soil erosion.

Minor concept(s)	Suggested Teaching Strategies
	The following activity may be performed: Card board boxes of equal size may be placed with same amount of garden soil. In one box some grass plants may be planted while the other box is left without any plant. Let the two boxes be placed inclined at an 45°. Add equal quantity of water in the two boxes. Ask the trainees to note how water is flowing with lot of soil particle from Box without plant in it. Water from box with grass plants flows out without many soil particles.
	iii) Teacher educator will explain to the trainees that plant usually takes more water than it needs. This excess water is given off through leaf's stomata into the air as water vapour. This process of evaporation of excess water from the plant is called transpiration. This process has a great implication in decreasing temperature of atmosphere, formation of clouds and rain.
iv) Plants increase the soil fertility	iv) Plants after completing their life span die. The dead material decomposes and releases all the nutrients in the dead materials. This increases the fertility of soil. Thus plants increase the soil fertility.

Minor concept(s)	Suggested Teaching Strategies
v) Plants serve welfare of human and all living beings	v) Teacher educators may describe in detail the contributions of plants to the welfare of human and all living beings. – Flowers can be used as decorative material. – Total plant used as food - cabbage, onion, spinach etc. – Plants in field and forests provide retreat where millions of people can enjoy peace and contentment. – Tea leaves and coffee seeds are used as drink – Flowers are the medium through which emotions such as love, sorrow, and worship can be conveyed often more effectively than through words. – Making fence with the help of *Acacia* sp. for protection. – Plants provide shelter to other animals and plants. – Plants are useful in different industries for textile, medicine, timber, spice, rubber, chemical etc. Teacher educator, as far as possible, may collect the living specimen of the plant to explain the various uses of the plant.

IMPORTANCE OF PURE WATER, FOOD AND AIR

	Suggested Teaching Strategies
Major concept(s) 1. Maintenance of water sources is necessary for good health and existence of life **Minor concept(s)** i. Drinking water sources are to be free from sewage waste water. ii) Pure water keeps the body health. iii) Different water bodies should be kept away from pollution iv) Wastage of water needs to be prevented. v) Ways of purification of water vi) Importance of storing water in germ free vessels vii) Effects of polluted water on animals including human beings.	Teacher educator must discuss about properties of water, sates of water, different sources of water such as ponds, lakes, river, oceans, dug well, deep tube well etc. Teacher trainees should be well aware of importance of maintenance of different sources of water free from germs and waste water for keeping good health of living beings including human beings. Field trips can be arranged so that pupils understand the sources of water and necessity of maintenance of different sources of water free from pollution. Teacher educator must discuss what role teacher trainees can play to make aware of the children/pupil keeping drinking water clean and need for conserving the precious water. **Teacher trainees pupils activity:** Teacher educator may demonstrate water purification by filtering. A large plastic or glass funnel is placed in a narrow mouth glass jar. Different filtering substances like a bed of small pebbles, then a layer of gravel, coarse sand, and finally a layer of fine sand is added in this funnel sequentially. To allow the different layers to settle and pack together, firstly some amount of clean water is poured through the funnel. Then pour some muddy water into the funnel. The filtering medium will filter the mud, and clear water will pass into the jar.

	Suggested Teaching Strategies
Major concept(s) Hygienic foods keep good health **Minor concept(s)** i. There are different sources of food ii) Importance of eating hygienic food iii) Eating all kinds of food keeps good health iv) Wastage of food should be avoided	Teacher educators are to explain the importance of eating hygienic food, different kinds of food and their sources like bread made of floor, from wheat maize bajra, gram and rice from paddy etc. Necessity of all kinds of foods like ghee, oil, gur, sugar, pulses, curd, milk and fruits need to be discussed so that teacher trainees can make the pupils aware of sources of nutrition for keeping good health. Teacher trainees/pupils can list the sources of food from living things around them.

Food from plant sources:	Food from animal sources:
a)	a)
b)	b)
c)	c)
d)	d)

a) Teacher trainees can list the vegetables as eaten generally at home in tabular form

Eaten raw vegetables	Eaten cooked vegetables	Eaten both raw and/or cooked
a)	a)	a)
b)	b)	b)

	Suggested Teaching Strategies
Major concept(s) Composition and properties of air **Minor concept(s)** i) Air occupies space ii) Air is a mixture of gases iii) Air gets polluted by gasses and solids iv) Gases of air are colourless, odorless and tasteless v) Air has no shape of its own vi) Air is invisible vii) Air has weight viii) Air has pressure ix) Air maintains combustion	Teacher educator may explain to the teacher trainees that air is found around us. It occupies the space all around the earth. It is also found in soil, water, between particles of porous materials as sponges, bricks, wood, and bread. Teacher educator should discuss the composition of air: two principal gases of air i.e. oxygen (21 percent) and about four fifths of the air is nitrogen (78 percent). Together these two gases make up about 99 percent of the air. The remaining 1 percent of the air comprises carbon dioxide gas, hydrogen gas, and a group of rare and inactive gases like helium, neon, argon, krypton and xenon. Trainees should be told that all animals and plants need oxygen for breathing and digesting their food. Plants use carbon dioxide to make food which is used not only by plants themselves but by animals as well. It needs to be highlighted that air also contains invisible gas, called water vapour, carries dust, pollen, plant spores and waste gases which in turn cause respiratory diseases and several physiological complications of animals including human. Teacher educator may explain the properties of air. Teacher trainees should understand that different gaseous components of air are odorless, colourless and tasteless. A clear idea is to be given that air takes the shape of the container like water it fills, clarifying that it does not have its own shape. Though air realy takes up space, it is invisible. Teacher educator may explain that 1 litre of air weight about $1\frac{1}{5}$ grams (1 cu ft. weighs about $1\frac{1}{4}$ oz). As air has weight, it pushes or presses against things. Teacher trainee's should understand that we all live at the bottom of an ocean of air hundreds of kilometres or miles high. Air presses down on the earth's surface and

creates a pressure on it which is called air pressure. Air gets polluted by smokes of different sources, radioactive particles and plant spores calling immediate necessity to control air pollution to save living beings.

a) **Teacher trainees activity :** Teacher educator may demonstrate that air occupies space. Teacher trainees are asked to bring a dry paper napkin, a tumbler, an aquarium or a large glass jars and water. First, the tumbler contains a crampled dry paper napkin inside it such a way, so that it does not fall out when the tumbler is held upside down. Now, push the upside down tumbler straight down to the bottom of large jar filled with water. Finally lift, the tumbler out of the jar, remove the paper napkin and note that it is still dry. Teacher educator explains that water does not fill the tumbler as the space in the tumbler is occupied by air.

b) Teacher educator may demonstrate that air exerts pressure. Teacher trainees are asked to perform the activity: Place a card board on top of the tumbler filled with water. While holding the card board firmly against the tumbler with the palm of one hand, grasp the base of the tumbler with the other hand and quickly turn the tumbler upside down. The cardboard and the water will remain in place after careful removal of the palm of the hand. Teacher educator explains that the water stays in the tumbler because air is exerting a pressure on the cardboard. When the tumbler is turned sideways and in many other positions, water will still stay in the tumbler, explaining that air exerts pressure in all directions.

	Suggested Teaching Strategies
c)	The teacher trainee will blow air in choked football bladder or plastic bags and try to inflate them. From this, they will understand that the pressure of air is causing the inflation of the bladder or bags. The teacher-educator will discuss about pressure of air and will draw necessary diagram. Teacher-educator will give examples like bursting of airfield cycle tube, balloon etc. which they observe in every day life. Besides, the air brake uses compressed air to stop trains, street cars, buses, heavy trucks, etc.
d)	Pupils activity : The students will ignite two identical candles 'A' & 'B', one (A) will be covered by a transparent glass and the other 'B' will remain uncovered. Teacher will accept the conclusion that a candle will not continue to burn in a small closed space. It shows the need for a continuous supply of fresh air to maintain combustion. They will observe that 'B' is burning and 'A' is extinguished and understand that air helps in burning of candle as in the case of 'B'.

FORCE AND WORK

Teacher trainees will be able to:

1) demonstrate the change of motion by the application of force

2. demonstrate the application of muscular force

3. give examples of applications of muscular forces by different animals

4. know that force is required to do work

5. know methods of reducing friction

6. perform simple activity to compare weights of different bodies

7. perform activities to demonstrate frictional forces

8. compare the useful and harmful effects of friction

9. describe some of the unusual situations in the absence of friction.

Major concept(s)

1. Force is required to do any work

Minor concept(s)

a) Force is a push or a pull
b) Force changes state of motion
c) Force has magnitude and direction
d) Applied force and work has a relation

Suggested Teaching Strategies

Teacher educator explains that a force is a push or a pull. A force must be used to make a machina work. A force may be produced by the following: i) Electricity, ii) Steam, iii) Gasoline, iv) Wind, v) Earth's gravity, vi) Falling water, vii) Sun's rays, viii) Springs and weights, ix) Muscles

Teacher educator can explain the muscular force through several demonstration performed in the class i.e. lifting the books from the table, writing on the black board, pushing of chair, kicking a ball and so on. All these actions involve the muscular force.

Teacher trainee/pupil activity : 1

The students will pull a brick or duster placed on the table. They will distinguish the variation in the magnitude of forces in two different cases of work done on brick and duster.

Teacher trainee/pupil activity : 2

The trainees/pupils will apply force on the wall to move and as well give force on the duster placed on the table to displace the same. They will realise that with the application of force, they could not make the wall to move while the duster changed its position. From this, the teacher will explain the work is done on duster and no work done on the wall.

Suggested Teaching Strategies

The trainees/ pupils give examples from field observation where different types of muscular forces like push, pull, twist, lift etc to do different works. The teacher educator will explain the type of muscular force applied to pull a bullock cart, to lift water from the tubewell, to row a boat in the river, to open a door or window, unlocking an almirah, twisting wet towels / napkins etc.

The trainees/pupils will observe different examples of falling bodies like leaves from tree, a piece of chalk falling from the hand, falling of rains etc.

The trainees/pupils will hold science notebook and the duster and try to understand which one is heavier. It will be followed by discussion by teacher educator to explain the cause behind the falling bodies. It is a kind of attraction between the earth and the body and due to this force of attraction the body falls to the ground. This force of attraction is known as gravitational force or gravity due to earth.

Teacher trainee/pupil activity : 3

To demonstrate the relation between the weight of a body and gravitation, each of the following experiments can be performed.

A piece of cloth is stretched on both sides on two iron stands. Two pieces of bricks, one larger and the other smaller are placed along the length side by side, such as two are separated at same distances from the middle point of the cloth. From the observation, it will be found that the cloth below the larger brick is depressed much more than the smaller one. Then the teacher educator will discuss, that the heavier

Suggested Teaching Strategies

body will be attracted strongly towards the ground than the lighter one due to greater weight of the former.

Major concept(s)

2. Forces are of different types

Minor concept(s)

a) Force exerted with the help of the muscle is muscular force
b) All freely falling bodies move towards earth due to gravitation
c) Gravitation and mass of a body has relation
d) Friction is the force that resists the movement of one material over the other.
e) Methods of reducing friction

Teacher educator will explain that friction is the force that resists the movement of one material over another material. Whenever the surfaces of two materials rub against each other, some friction is produced. Trainees/pupils will understand that friction is caused by the irregularities in the surfaces of materials. When two surfaces are rubbed together, the bumps and hollows present on rough or smooth surfaces, catch and stick and resist the movement of the surfaces over each other. Friction is also caused by the attraction of the molecules of one surface to the molecules of another surface as the surfaces rub against each other. Whenever there is friction, heat is produced. Friction can make ti hard to push one material across another material.

Teacher trainees/pupils activity : 1 Trainees/pupils will discover why uneven surfaces cause friction. Teacher educator will ask trainees/pupils to rub two pieces of wood with rough surfaces together. Observe that the friction produced. Ask them to examine the surfaces under a magnifying glass and note the bumps and hollows.

Teacher trainees/pupils activity : 2 Trainees/pupils will observe that friction produces heat. Have the trainees/pupils rub the palms of their hands together briskly and note the heat produced by the friction. The more briskly the hands are rubbed, the greater the friction, and the hotter the hands become.

	Suggested Teaching Strategies
f) Friction force is advantageous as well as disadvantageous in our day to day life	Teacher educators may discuss various methods reducing friction. Making the surfaces smother levels out the bumps and hollows and reduces the friction between them. A slippery material, called a lubricant reduces friction. Oil, grease, glycerine, water, soap, candle wax and graphite can be used to reduce friction. Rollers, wheels or ball bearings reduce friction. Streamlining reduces the friction of the air rubbing against moving autos. Teacher educator may tell that the shapes of fish and birds are used in streamlining. Planes and trains are also streamlined to reduce friction. **Teacher trainees/pupils activity : 3** Teacher educator will help the trainees/pupils to discover that lubricants reduce friction. Ask them to rub two pieces of dry toast together. Observe the amount of friction and also the wearing away of bits of toast. Now spread some jam thickly across each piece of toast and rub the pieces together again. Observe the pieces will now slide smoothly over each other because the jam filled the hollows and covered the bumps, reducing the friction. **Teacher trainees/pupils activity : 4** Teacher educator will help the teacher trainees to discover that wheels reduce friction. Trainees/ pupils can obtain a large cardboard carton the same size as the body of a pupil's play cycle/wagon. Place one pupil in the carton and have another pupil push the carton across the floor. Now ask the pupil in the carton climb into a play cycle/wagon and have the second puple push the wagon/play cycle across the floor. Point out the amount of force required to push the carton and the wagon/play cycle.

Suggested Teaching Strategies

Teacher educator will explain the useful and harmful effects of friction. Friction can be useful: i) Without friction we could not walk because our feet would slip, ii) Without friction we could not write with a pencil, pen or chalk, iii) Auto brakes use friction to slow down or stop a moving auto, iv) Friction is useful in making things smoother, like sanding wood or grinding lenses, v) The heat caused by friction makes a match burst into flame.

Friction can be harmful : 1) Friction wears away things. Automobile tires, shoes, and clothing are worn away by friction, ii) Friction makes work harder because extra force must be used to overcome friction, iii) Friction resists the movement of objects, iv) Friction between air and moving objects hinders the speed of these objects, v) Friction produces heat which may cause machine parts to melt and bend, vi) At high speed the friction between the air and a plane or rocket may cause parts of the plane or rocket to become so hot that they will burn up, melt, or bend.

Teacher trainee/pupil activity : 5 Teacher educator may help the trainees/pupils to compare useful and harmful effects of friction. Trainees or pupils can make two columns on the chalk board. In one column, trainees/pupils will make a list of useful effects of friction. In the second column they will make a list of harmful effects of friction.

Teacher educator will ask the trainees/pupils to describe some of the unusual situations that would happen if there were no friction on earth.

SOME PHYSIOLOGICAL PROCESSES IN THE HUMAN BODY

	Suggested Teaching Strategies
Major concept(s) Make up of the human body Minor concept(s) i) Human body consists of cells ii) There are many tissues, organs and systems in the human body iii) Human body comprises of three regions	Teacher educators should explain the constituent unit of human body, different tissues and systems so as to facilitate the trainees/pupils understand the make up of the human body. Millions of cells contitute the human body. Teacher educator may give examples of special kinds of cells such as blood, epithelial, muscle, nerve and bone cells. Trainees/pupils must be given the information that cells of same kind carrying out same activity called a tissue. Such tissues are muscle tissue, nerve tissue, epithelial tissue, connective tissue and blood although a liquid is also a tissue. Likewise, a group of different tissues, working together is called an organ such as heart, lungs, liver, stomach, eyes and brain. Teacher educator needs to tell the trainees/pupils the following ten large systems in the human body. (1) skin system, (2) skeletal system, (3) muscular system (4) digestive system (5) circulatory system, (6) respiratory system (7) excretory system, (8) nervous system, (9) reproductive system and (10) endocrine system. Human body has three regions, the head, the trunk and the limbs (arms and legs). Teacher educator may explain the following large systems in human body.
Major concept(s) Respiration is the vital function in the human body	i) Respiratory system : Teacher educator will explain that respiratory system comprises of several parts such as nose and nasal passages, the throat or pharynx, the wind pipe or trachea, the voice box or a larynx, the bronchi, the bronchial tubes, and the lungs. The function of this system is to bring oxygen into the body and to get rid of carbon dioxide.

Minor concept(s)	Suggested Teaching Strategies
i) Lungs consist of a great mass of air sacs ii) Breathing differs from respiration iii) Cells in the body use oxygen and give off carbon dioxide in respiration vi) Lungs are the sites of exchange of oxygen and carbon dioxide	The cells of the body take in oxygen, use oxygen to burn the digested food and produce heat and energy, and then give off carbon dioxide called respiration. Trainees must understand that the bottom of the wind pipe (*trachea*) divides into two branches, called *bronchi* and each branch enters one of the lungs. The bronchi divides into smaller branches called *bronchial tubes*. The bronchial tubes keep branching until the smallest tubes end in clusters of little sacs called *alveoli* (like clusters of grapes). Each lung is one great mass of these clusters of air sacs. Teacher educator should distinguish between breathing and respiration. Breathing refers to only to the process of getting air containing oxygen into the body and getting air containing carbon dioxide out of the body. Trainee's/ pupil's understanding how respiration takes place needs to be clarified by teacher educators. Trainees/pupils must understand that the air sacs in the lungs are surrounded by millions of capillaries. The oxygenated air that comes into the lungs passes through the thin walls of the air sacs and through the thin walls of the capillaries into the blood. Erythrocytes (red blood cells) take up the oxygen and becomes bright red. The blood passes from the lungs to the heart, which pumps it through the arteries and capillaries to every part of the body. The cells in the body use the oxygen to oxidize digested food producing heat and energy and giving off carbon dioxide. The red blood cells take up the carbon dioxide and looks dark red. The blood passes through capillaries and veins back to the heart. The heart sends the blood containing the carbon dioxide to the lungs. In the lungs, the carbon dioxide leaves the blood and passes out through the thin walls of the capillar ies and through the thin walls of the air sacs in the lungs. The air having carbon

dioxide is forced out of the lungs, and fresh air containing oxygen is forced in the lungs. This action of getting oxygen into the body using oxygen to produce heat and energy and getting waste carbon dioxide out of the body goes on all the time.

Teacher trainee / Pupils activity : 1

Pupils may be asked to obtain a chart or draw a diagram of the respiratory system. They may be helped to locate and identify the nose, nasal passages, pharynx, trachea, larynx, bronchi, bronchial tubes and lungs. Teacher educator may help the trainees while discussing the function of each of these parts in the process of respiration.

Teacher trainee / Pupils activity : 2

Instruct trainees/pupils to obtain a portion of the lung of a sheep, pig or hen from the meat market. They will observe how spongy the lung tissue is. Examine a section of this lung tissue under the low power of a microscope/magnifying glass and locate a cluster of many air sacs that are found throughout the tissue.

Pupils activity : 3

Pupil could observe the effect of exercise on the rate of breathing. Teacher trainee may help the pupil in doing this activity in individual pupil. Have one pupil place his hand on another pupil's chest and count the number of times the pupil is breathing in 1 (one) minute. Teacher trainee may tell the pupil that one inhalation and one exhalation together count asjust one breath. Now have the second pupil exercise until he or she is breathing quite heavily and then let the first pupil count the number of breaths in 1 minute.

Major concept(s)

Circulation assumes great significance in the human body

Minor concept(s)

i) Blood has liquid and solid materials

ii) Blood moves in closed tubes

iii) Heart, a strong muscle, acts by contracting and relaxing

iv) Heart has four chambers

(v) Circulation of blood is going to both lungs and the body and returns

Suggested Teaching Strategies

ii. Circulatory system : Teacher-educator needs to explain that circulatory system comprises of heart, blood and blood vessels. Trainee/pupil should have clear understanding of blood as a tissue. This tissue has a liquid part called plasma containing mostly water,sodium chloride, calcium salts, protein fibrinogen, antibodies and hormones. Solid materials in blood are red corpuscles, white corpuscles and platelets. Red cells contain an iron compound called haemoglobin which gives them their red color. Red blood corpuscles take up oxygen from the lungs and carry it to the cells in the body. It also picks up carbon dioxide which is produced in the cells, and carries it to the lungs where the CO_2 is given off. The colourless larger white corpuscles, leave the walls of the blood vessels and move around among the cells in the body to destroy disease germs. Colourless, smaller than red cells, platelets help blood clot when the body is injured and bleeds. Teacher educator may provide the information that the normal temperature of an adult's blood is about 37°C (98.6° F). Trainees must have clear understanding about blood vessels. Teacher-educator may explain three kinds of blood vessels in the body : i) *arteries, veins* and *capillaries*. Arteries are blood vessels that carry blood away from the heart. Veins are blood vessels that carry blood back to the heart. Capillaries are very tiny blood vessels between the smallest arteries and veins. Trainees should know that all the cells in the body are next to some capillary. Here teacher educator may explain that the walls of the capillaries are so thin that molecules of materials in the blood can pass into the cells and molecules of materials in the cells can pass into the blood. The blood gives the cells food, oxygen and minerals, whereas the cell gives the blood carbon dioxide and other waste materials. Teacher-educator may facilitate understanding of trainee/pupil of the organ heart. Heart is

a pear shaped strong muscle and as big as a fist. It is located to the left of the middle of the chest. It has four compartments: the top two chambers/ compartments are called *auricle* and the bottom two chambers are called ventricles. Trainees/pupils must know that the auricles receive blood from the veins in the body and pump it down into the ventricles when the ventricles pump the blood into the arteries in the body. Teacher educator should also explain that the heart has valves that prevent the blood from flowing back into the auricles when ventricles are contracting. The large arteries have valves, which are located just where the arteries leave the heart. Veins also have valves located all through the body which prevent the blood from flowing back and in this way force the blood to move towards the heart. Trainees/pupils should also understand the pulse beats. A pulse is the beat that can be felt in the arteries every time the heart contracts or beats. This pulse can be felt by placing the finger over an artery in the wrist or neck. Trainee/pupil can find out how fast the heart is beating, or contracting.

Teacher educator will explain in detail the circulatory system in the body so as to facilitate trainee /pupil to grasp it easily. Trainee/pupil should know that in one system, blood coming from all over the body enters the right auricle of the heart, pumps to right ventricle then pumps the blood to the lungs. Here, the blood contains carbon dioxide. When the blood is sent to the lungs, it gives up the carbon dioxide and picks up oxygen. In the other system, blood coming from the lungs, enters the left auricle of the heart, pumps, the blood down to the left ventricle and then pumps the blood to the parts of the body. In this case, the blood brings fresh oxygen to the cells in the body, gives up the oxygen to the cells, and at the same time picks up carbon dioxide, which it brings back to the heart.

Suggested Teaching Strategies

Trainee/pupil should also understand the function of circulatory system. Teacher educator may clarify their doubt if at all needs arise. The circulatory system carries digested food to the cells in the body. It brings oxygen to the cells for oxidizing the food and producing heat and energy. This system also takes away the waste materials produced by the cells and carries these materials to organs that remove them from the body

Trainee/Pupil activity : 1 Teacher educator may help the trainee/pupil to examine blood. Instruct the trainees to wash their hands thoroughly and then rub a piece of cotton dipped in alcohol over one finger tip. Prick the finger tip with a sterilized needle and squeeze out a drop of blood. Press the blood against a clean microscope slide and cover with a cover glass. Instruct the trainee to observe the blood under high power of a microscope. Trainee /pupil will observe many disc shaped red corpuscles and one or two white corpuscles. Teacher educator may discuss the role of platelets in clotting.

Pupil activity : 2

Pupils by using the first two fingers of their right hand, feel for the pulse on their left hand at the base of the thumb where the left hand joins the wrist. Teacher trainee may tell the pupil to count the number of pulse beats in 1 minute. Now instruct the pupils jump up and down for number of times (10 or 15 times) or exercise vigorously and count their pulse beat for 1 minute again. Pupil will note how faster the pulse beat becomes.

Teacher educator may also help the teacher-trainee pupil to examine an animal heart after obtaining the heart of sheep, pig or hen from the meat market.

Suggested Teaching Strategies

Trainee/pupil activity : 3

Teacher trainee/pupil may obtain a chart or draw a diagram of the human circulatory system. They can trace the circulation of an imaginary bubble of blood through the body. First, have the blood leave the heart, pass through the body to the legs and return to the heart. Finally, have the blood go to the lungs and back. Teacher educator may help the trainees to follow the movement of the blood through the different auricles and ventricles of the heart.

Major concept(s)

Digestion constitutes an important phenomenon in the human body

Minor concept(s)

i) Special organs make up the digestive system in the body
ii) Mouth prepares food for digestion
iii) Salivary glands help in digestion
iv) Gastric juice breaks food proteins into simpler units
v) Pancreatic and intestinal juices contain many enzymes.

Teacher educator should give a clear cut idea about the digestive system. Trainee/pupil should know that the digestive system has two parts: alimentary canal and the digestive glands. The alimentary canal or the food tube includes the mouth, throat or pharynx, gullet or oesophagus, stomach, small intestine, large intestine, rectum and anus. The digestive glands include the salivary glands, liver, pancreas, the gastric glands of the stomach and the intestinal glands of the small intestine. Teacher educator will describe how the food substances are broken into smaller pieces with the help of teeth (16 teeth on each jaw) and digested when saliva from three pairs of salivary glands are mixed with foods. Trainee/pupil should have the knowledge of gastric glands and action of gastric juice secreted through ducts into the stomach. Gastric juice contains many enzymes which convert protein into simpler units and also contains hydrochloric acid which kill many germs that enter into stomach with the food. Teacher educator may highlight the importance of intestinal juice, pancreatic juice and bile from liver in digestion of fat, carbohydrates, and proteins into simple dissolved forms. Small intestine contains villi

	Suggested Teaching Strategies
vi) Blood vessels of villi take in dissolved food	which absorb dissolved food which are taken in by the blood vessels of the villi. Finally blood stream carries the food to cells in all parts of the body.

Pupil activity : 1

Teacher trainee may help the pupil to obtain a chart or model of the body cavity with the digestive organs in place. Ask the pupil to note how the oesophagus or gullet, stomach, small intestine, and large intestine form one long, continuous tube for passageway through which the food moves in the body.

Teacher trainee/pupil activity : 2

Trainee/pupil should draw a diagram of the number of teeth that should be in the mouth using 'U' shape to represent the jaw. Have pupils to examine their teeth with a regular mirror and note which of these permanent teeth they already have. Teacher trainee may draw the diagram showing structure of a tooth and discuss proper method of brushing the teeth.

Teacher trainee/pupil activity : 3

Teacher educator may instruct the trainee/pupil to obtain or draw a chart of all the organs of the digestive system. Teacher educator may help them in tracing the digestion of food. Have the trainee/pupil trace the digestion of a bread omelet (having carbohydrate, fats and proteins) from the time it enters the mouth until the waste products leave the body. Teacher educator may discuss the function of each organ in digesting these foods.

Major concept(s)

Human body gets rid of waste materials

Minor concept(s)

i) Human body produces waste materials

ii) Ways of removal of waste materials are many

iii) Excretory system includes organs such as kidneys and bladder

Suggested Teaching Strategies

Teacher educator will define excretion as a process for removal of waste materials from the body. Waste materials produced by the human body include i) carbon dioxide, excess water, digestive juices left behind after digestion, worn out or broken down cells, tissues and muscles, mineral salts and nitrogen compounds, undigested and unused food. Trainee/pupil must be well aware that human body gets rid of these waste materials in different ways: i) The lungs give off CO_2 and some water as water vapour, ii) Skin gives off perspiration which contains water and dissolved mineral salts.

Teacher educator will discuss about kidneys in detail while highlighting its role in the removal of waste materials. Trainee must know that kidneys are two dark red, bean shaped organs located in the lower part of the back. Each kidney is packed with millions of tiny tubes which play vital role in removing from the blood such waste materials as mineral salts and protein compounds. These waste together with excess water form a liquid called **urine**. Finally, the urine flows from the kidneys through two tubes, called **ureters** to a storage organ called the **bladder**. Trainee/ pupil will also learn that the undigested and unused food, together with used digestive juices, pass/through the large intestine and out of the body as **feces**.

Pupil activity : 1

Pupil can observe the excretion of water. Let the pupil recall the perspiration drops, containing water that formed on their faces and bodies on a warm day after they had been running or playing actively.

Suggested Teaching Strategies

Teacher trainee/ pupil Activity : 2

Trainee/pupil will observe the excretion of carbon dioxide. Teacher educator may instruct them to get lime water and pour a little into a test tube . Allow one of the pupils/trainees bubble the lime water with a soda straw until the lime water becomes milky indicating the presence of carbon dioxide. The carbon dioxide came from the air inside the pupil's/trainee's lungs

Pupil activity 3

Have the pupils lick their wrists after they return from a recess period where they have been playing actively. Explain them that the salty taste is caused by the presence of mineral salts, which were dissolved in the perspiration and left behind after the perspiration evaporated. Teacher educator may obtain a chart or draw a diagram showing kidneys and different parts of the excretory system and discuss the function of each part in excretion. Teacher trainee may help the pupil in obtaining kidney of a hen, pig or sheep from the meat market and observe the size and shape of the kidney.

Major concept(s)

Sensations come from five sense organs in the human body

Teacher trainee/pupil may be aware of senses of human beings. Teacher educator may help them how sense organs produce special sensations. It is the nervous system that makes possible for the human body to have many sensations. Sensory nerves located in sense organs send nerve impulses to the brain which recognizes these impulses as sensation. Human body produces many sensations such as sight, hearing, smell, taste, pain, pressure, cold, heat, touch and balance. These sensations come from five sense organs: eyes, ears, nose, tongue and skin.

Minor concept(s)	Suggested Teaching Strategies
i) Human body have many sensations ii) Sensation of sight comes from eyes	Teacher educator may facilitate the trainee/pupil to understand how sensation of sight comes from eyes. Human eye is shaped like a ball and is called the eyeball. Dark opening in the eye called the pupil allows light to go into the eyeball. Teacher educator will discuss how we experience sight. Trainees understand that inside the eyeball, is convex lens which is thick in the middle and thin at the ends. A sensitive lining called retina is seen at the back of the eyeball. The retina houses tiny sensitive nerve endings, leading to the optic nerve. When light strikes the retina, the tiny nerves carry impulses through the optic nerve to the brain, where we experience the sensation of sight. Teacher educator should discuss on defects of the eye such as near sightedness, farsightedness and color blindness. **Teacher trainee/pupil activity** The teacher educator may ask the trainee/pupil to obtain a chart or model of the human eye. Ask them to locate and discuss of the main parts including cornea, pupil, iris, lens, two liquids (vitreous and aqueous), retina and optic nerve.
iii) Sensation of hearing comes from ear	Teacher trainees/pupils are to understand that ear has three parts: the outer ear, the middle ear and the inner ear. Teacher educator must describe these parts so as to facilitate trainees/pupils understanding. The outer ear collects the sound waves and sends through a tube called eardrum (a piece of tissue) to the middle ear. When the sound waves strike the eardrum they make it move back and forth rapidly or vibrate. The middle ear passes the vibrations of the eardrum to the inner ear. The hearing part of the inner ear is a spiral passage, called the cochlea that remains filled with a liquid. When the inner ear vibrates, the liquid inside the cochlea begins to vibrate. The tiny nerve endings receive the

vibrations of the liquid and send impulses to the auditory nerve. The auditory nerve carries these nerve impulses to the brain, where we get the sensation of sound.

Teacher trainee/pupil activity : 1

Trainee/pupil may be asked by the teacher educator to bring a chart or model of the ear. Ask the trainee/pupil to locate and discuss the function of the main parts of outer, middle and inner ear.

Pupil's activity : 2

Teacher trainee may ask one pupil to sit in the centre of the room with keeping eyes closed. Tell another pupil to stand at different locations in the room and strike two pencils together. 1st pupil at the centre will be able to tell from what direction the sound is coming because the sound usually reaches one ear sooner than the other. Now have the 1st pupil at the center place one finger in his ear. Repeat the striking of two pencils by the second pupil standing at different locations in the room. This time pupil at the center will have difficulty telling from what direction the sound is coming.

iv) The sensation of taste is located in the tongue

Teacher educator will clarify that the sensation of taste is located in clusters of cells called taste buds that are spread unevenly over the tongue. They must help the trainee/pupil to understand that these clusters of cells contain nerve endings that are sensitive to taste. The taste comes from chemicals in the food, which must first be dissolved in the saliva before the taste can be sensed. The taste buds can recognise only four flavours: sweet, sour, salty and bitter. The teacher educator may clarify to the trainee/pupil that the taste buds at the

tip of the tongue are sensitive to sweet and salty flavors. The taste buds along the sides of the tongue are sensitive to bitter flavors. Trainee/pupil should also understand that many food have more than one flavors.

Teacher trainee/pupil activity

Teacher educator may help the trainee/pupil to investigate the sense of taste. Have a pupil/trainee stick out his tongue keeping his eyes closed. Dip an absorbent cotton stick into a solution of sugar and water. Touch the cotton to the tip, sides, and back of the tongue. Have the pupil/trainee identify the taste as sweet, sour, salty bitter in each case. Make sure the pupil's/trainee's tongue is moist with saliva. Repeat, using salt solution, lemon juice, and a bitter solution of an aspirin tablet in a small amount of water, rinsing the mouth after each test. Trainee/pupil will detect sweet flavours mostly at the tip of his tongue, salt flavors at the tip and front sides, sour flavors along the sides and bitter flavours at the back of the tongue.

(v) Smell sensation comes from the nose

Teacher educator will explain that nerve endings in the nose are sensitive to chemicals in the air that are breathed in. These chemicals get dissolved in the mucus liquid that covers the lining of the nasal passage. Teacher educator will further explain that when the nose smells the same odor for a long time, the nerve endings become sensitive to that particular odor and we experience smell sensation of that odor. Then there is no more sensation of smell for that odor. Trainee/pupil should also know that human's sense of smell is poor compared to many animals, such as deer and the dog.

Suggested Teaching Strategies

Teacher trainee/pupil activity

Have the trainees/ pupils sit quietly in the class room. Pour some inexpensive strong perfume on a handkerchief and wave the handkerchief in the air. Ask the trainee/pupil to raise their hands as soon as they smell the perfume. Point out that the odor diffuses progressively to all parts of the classroom.

vi) Different kinds of sensation come from the skin

Teacher educator will clarify that the skin has different sensory nerve endings responsible for different kinds of sensation. These sensations include touch, pressure, heat, cold and pain. The sensory nerves spread unevenly over the skin consequently the skin is more sensitive in some parts than in others. Teacher educator will make it clear that the finger tips and the fore head have a great many nerve endings that are sensitive to touch. The nerve endings sensitive to touch are very near the surface of the skin, but the nerve endings sensitive to pressure are located deeper inside the skin.

Teacher trainee/pupil activity

Teacher educator may help the trainee/pupil to investigate sense of touch. Trainee/pupil may touch the point of a thin, sharp nail to different spots, front and back of their fingers. In some spots they will feel only a sense of pressure. Other spots, which are more sensitive, will also produce a feeling of pain.

THE UNIVERSE
(THE SUN, THE EARTH AND THE MOON)

The Teacher trainees will develop competencies in many directions. The teacher trainee will able to

1. discuss the real and apparent shape of the earth.
2. explain why the earth looks like a flat body
3. impart knowledge why upper surface of the earth looks like a plane rather curved
4. perform experiments to explain and demonstrate the apparent and real shape of the earth
5. explain and demonstrate the causes of shadow formation
6. compare the size of the sun and the earth
7. understand how we see planets by reflected light
8. observe morning and evening stars and to note of their position and appearance
9. to demonstrate how the sun causes day and night
10. explain why the sun is red at sunrise and sunset
11. observe and compare phases of the moon
12. explain how does the moon cause tides
13. demonstrate the solar and lunar eclipse
14. impart knowledge and demonstrate how to watch a solar eclipse.

	Suggested Teaching Strategies
Major concept(s) Stars in space **Minor concept(s)** i) Stars produce their own light ii) Stars seem to twinkle iii) Stars differ in colour, age and temperature iv) Stars differ in size	Teacher educator may play vital role in explaining the Universe and help the trainee or pupil to have clear conception. Stars are suns in space, and they produce their own light. Of the countless stars in the sky only about 3000 can be seen with the naked eye. Trainees/pupils are aware of that stars are not in a fixed position because they move rapidly through space in all directions. Small stars, like the Sun, are called dwarfs and large stars, like Pegasi, are called giants and very large stars like Betel geuse, are called supergiants. Teacher educator will make it clear that stars differ in colour, depending upon the age and temperature. Surfaces of older stars become cooler and change color. There are Blue-white or White (youngest) star (surface temperature about 7500° to 30000° Celsius), Yellow star (surface temperature about 6000° Celsius), Orange star (surface temp. 4000° Celsius) and red star (oldest, surface temperature about 3000° celsius). Our Sun is classified as a yellow star. The brightness of a star depends upon its temperature, size, and distance from the earth. The stars are so far away that they are only small dots of light when we look up at them. Movement of the earth's air make thin rays of light from these distant stars move back and forth or twinkle.
Major concept(s) The Sun is star	Teacher educator may help the trainee/pupil to gather more knowledge about the Universe. The Sun is a star. The Sun is one of the billions of stars make up the Universe. It is not a large star, but it looks larger than the other stars because it is so much closer to us on earth. Trainee/pupil should know that the Sun is much larger than the Earth. The diameter of the Sun at its equator is about 1,380,000 kilometers (860,000 miles) which is about 109 times larger than the diameter of the earth. The Sun is about 150,000,000 (15 million)

Minor concept(s)	Suggested Teaching Strategies
i) The Sun possesses unique nature ii) Sun emits radiant energy	kilometers (93,000,000 miles) from the Earth. Teacher educator will explain trainee/pupil that the Sun is not a solid body like the Earth, but it is a huge ball of very hot gases. The Sun has three layers of gases such as: photosphere which is the source of most of the Sun's light, chromosphere and corona that surround the main body of the Sun. It gives off a vast amount of radiant energy including light, like all others stars. The energy comes from a nuclear reaction i.e. conversion of hydrogen atoms into helium atoms with release of radiant energy. This reaction makes the Sun very hot. The Sun's surface temperature is about 6000° Celsius and temperature at the centre is estimated to be about 15,000,00° Celsius. Astronomers think that the Sun has been producing energy for about five billion years and will continue to produce energy for many billions of years more. They further predict that when enough of the hydrogen has been used up, the Sun will suddenly collapse and become so small in its size and its light, become cooler and cooler and fainter and fainter, until it finally becomes completely dark and can not be seen at all. **Teacher trainee/pupil activity : 1** Teacher educator may demonstrate and compare the size of the Sun and the earth. Ask the teacher trainee to draw two circles, one with a diameter of 54½ centimeters (21 4/5 inch) labeled as Sun and the other with a diameter of ½ centimeter (1/5 in) labeled as Earth. Point out that the larger circle (Sun) will be 109 times larger than the smaller circle (Earth). Place the two circles 150 centimeters apart. Supposing 1 centimeter equals 1 million kilometers, then 150 centimeters would indicate the distance from the Sun. **Teacher trainee/pupil activity : 2** Teacher trainee/pupil should be told that Sun's radiant energy and light come from nuclear reaction that is continually taking place inside the Sun. Teacher educator should relate this reaction with that of a hydrogen bomb, which lasts only for a moment. Point out the difference in temperature at the surface and at the center of the Sun.

	Suggested Teaching Strategies
Major concept(s) The solar system is made up of heavenly bodies **Minor concept(s)** Members of solar system are called planets Nature of planets i) Satellites are moon	Teacher educator will explain solar system which is made up of a group of heavenly bodies. These heavenly bodies are called satellites. The principal members of the solar system are nine large bodies called planets. The names of the planets , in order of increasing distance from Sun are - Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto. These planets wander over the sky instead of appearing to stay in a fixed position like the stars. Teacher educator may distinguish between planets and stars. Planets are not stars. Stars shine because they give off light but planets shine because they reflect the light of the Sun or other stars. Planets are much smaller than the Sun and most of the other stars. Planets travel in an elliptical (oval) path, called an orbit, around the Sun. All the planets move or revolve in a counter-clockwise direction (from west to east) around the Sun. The time needed for a planet to make one complete turn or revolution, around the Sun is called the planet's year. Teacher educator will have to clarify that the planets spin like a top, or rotate, as they travel around the Sun. Planets rotate around an imaginary line, called an axis which runs through the north and south poles of the planet. Trainee/pupil should know that the time needed for a planet to make one complete rotation on its axis is called the planet's day. Most planets have their own smaller satellites that revolve around them. These satellites are called moons. Teacher educator may further explain that there are at least 45 moons discovered by astronomers: One for Earth, 2 for Mars, at least 16 for Jupiter, at least 17 for Saturn, 5 for Uranus, 3 for Neptune, and one for Pluto. **Teacher trainee/pupil activity** Teacher educator may help the trainee/pupil to investigate how we see planets by reflected light. Let a rubber ball represent a planet. The 'Planet' can barely be seen in a darkened room. In a room that can be completely darkened, the 'Planet' can not be seen at all. Let a

lighted flashlight (or torch light) represent the Sun. When the "Sunlight" of the flash light or torchlight shines on the "planet", the "planet" can now be seen, because the light is reflected to the eye. Planets do not give off their own light. Planets can be seen because they reflect the light given off by the Sun which is a star.

ii) Similarities among the planets
iii) Differences among the planets

The planets are all alike in certain features : i) They are satellites of the Sun, ii) They all revolve in a counterclockwise direction (from West to east), iii) They all rotate on their axis, iv) They all obtain their energy from the Sun, and v) They all contain the same basic chemicals although proportions are different.

Teacher educator will help the trainee/pupil to understand that the planets differ in their distance from the Sun, ii) They differ in size and heaviness, iii) They differ in the kind and amount of atmosphere they have, iv) They differ in the time it takes them to revolve around the Sun, v) They differ in the time it takes them to rotate once on their axis, and vi) They differ in the numbers of moons they have.

Minor concept(s)
iv) Plants revolve around the Sun

Teacher educator should also explain about comets and meteors of the solar system. Comets are bodies of the solar system, having long oval-shaped orbits that bring the comets very close to the Sun the Sun and then far out into the solar system. Meteors are the billions of fast-moving rocks of all sizes in the solar system. Teacher educator will explain why the planets revolve around the Sun. There are two conditions, affecting each planet at the same time, that keep the planets revolving around the Sun. First condition is the inertia of the moving planet. The second condition is the Sun's pull of gravity on the planet. Both inertia and gravity affect each planet at the same time and in such a way that the planet travels neither straight into space nor toward the Sun, but instead it travels around the Sun.

Suggested Teaching Strategies

Teacher educator will have to describe all the planets that keep revolving around the Sun. Mercury is the planet nearest the Sun and it is about 58 million kilometers away from the Sun. It is the smallest planet that can be seen near the horizon shortly after sunset or just before sunrise. It is sometimes called an "evening" or "morning" star, even though it is really a planet. Likewise Earth's moon, Mercury has no air or water.

Venus is the next closest planet to the Sun and it is about 107 million kilometers from the Sun. It is about as big as Earth and can be seen near the horizon as an "evening" star just after sunset and as a "morning star" just before sunrise. The atmosphere of Venus consists of 96.4 percent CO_2, 3.4 percent nitrogen and a trace of water. Venus is the brightest body in the sky next to the Sun and moon because its thick clouds reflect so much sunlight.

Minor concept(s)

v) Apparent shape of the earth appears flat

vi) Real shape of earth is spherical

Earth is the next planet after Venus and it is about 150 million kolometers (93 million miles) from the Sun. It has a diameter of about 12,600 kolometers (7900 miles). It revolves around the Sun once every 365 1/4 days and it rotates on its axis once every 24 hours.

The Earth rotates at its equator, at a speed of about 1600 kolometers (1000 miles) an hour. Earth has one moon. Earth is the only planet where the temperature of its surface is usually between the boiling and freezing points of water, so most of the water on Earth is found in the liquid state.

Mars is the next planet after Earth, and it is about 225 million kolometers away from the Sun. It is the next closest planet to the Earth. It is a small planet and revolves around the Sun once every 687 days, so its year is almost twice the length of Earth's year. Mars rotates on its axis once every 24½ hours, so its day is about the same as Earth's day. Mars has two small moons and has seasons just like Earth. Mars has an atmosphere, but its air is much thinner than that on Earth, so there must be very little oxygen and water vapour in its air.

Suggested Teaching Strategies

Jupiter is the next planet after Mars, and it is about 776 million kolometers from the Sun. It is the largest planet, with a diameter of about 139,000 kolometers, about eleventh times that of Earth. Jupiter appears as a very large "star" (though it is really a planet) in the sky. It revolves around the Sun once in about 12 years. It rotates on its axis once in about 10 hours, so it has a very short day. Its speed of rotation is very fast, that is about 40,000 kilometers an hour at its equator, or about 25 times faster than Earth's speed of rotation at the equator. This rapid rotation makes Jupiter flatten at its poles and bulge at its equator even more than Earth does. Jupiter has at least 16 moons. Scientist think that Jupiter is a giant ball of gas with an atmosphere of nearly 90 percent hydrogen and 10 percent helium, with only a trace of water.

Saturn is the next planet after Jupiter and it is about 1430 million kilometers from the Sun. It has at least 17 moons. It has a diameter of about 120,000 kilometers. It revolves once around the Sun in about 29½ years. It rotates on its own axis in about 10 hours. It is surrounded by seven broad rings that revolve at different speeds around it.

Uranus is the next planet after Saturn and it is about 2900 million kilometers from the Sun. It has 5 moons. Like Jupiter, Uranus seems to have a solid core, surrounded by an icy layer and a thick atmosphere of gases. When all he other planets rotate on an almost vertical axis like a top that is spinning the regular way. Uranus rotates on an almost horizontal axis, like a top spinning on its side.

Neptune is the next planet after Uranus and it is about 4500 million kolometers away from the Sun. It has three moons. Scientists call Uranus and Neptune the twin planets. They both are about the same size. They both are made up of a solid core, surrounded by an icy layer and an atmosphere of the same kinds of gases.

Suggested Teaching Strategies

Pluto is the last and most recently discovered planet in the solar system. It is about 5900 million kilometers away from the Sun. It revolves once around the Sun in about 248 years. It has one moon.

Teacher trainee/pupil activity

Teacher trainee/pupil may be helped by the teacher educator to observe morning and evening starts. The morning or evening stars are really planets. Planets, such as Venus and Jupiter are called morning stars when they are just above the horizon at sunrise and evening stars when they are just above the horizon. at sunset. These planets can be easily identified because they are brighter than the real stars at that time. Ask the trainee/pupil to observe the planets each day for a weeks. Tell them to note the time of their appearance and their position.

Teacher trainees/pupil activity : Trainee /pupils will put a 25 paise coin on a football. They will compare the shape of the coin with that of the football. Further teacher will help the students to compare the shape of the football with that of the earth and the shape of the coin with football ground or school play ground .

Teacher trainee may further perform an experiment by cutting a small part of a "water melon" and compare the shape and size of the part with the whole and in the same way compare the shape of the play ground with that of the earth.

Teacher trainees will perform a Magilan type experiment by moving a toy-car on the surface on an earthen round pitcher. They will see that toy-car reaches at the starting point after completing one complete revolution. Now the teacher educator will help the trainees to compare the shape of the earth with that of earthen pitcher.

Suggested Teaching Strategies

Major concept(s)

Effects of the Sun on the Earth

Minor concept(s)

i) The Sun causes day and night on earth

ii) Earth gets its light from the Sun

iii) The Sun seems to rise in the east and set in the west

Teacher educator will explain how the Sun causes day and night on earth. The Earth spins like a top, or rotates, as it travels around the Sun. The earth spins around an imaginary line, called an axis which runs through the earth's north and south poles. It rotates on its axis in a counter clockwise direction (from west to east). The earth is inclined at 23½° (23°30′) tot he vertical plane or 66½° to the horizontal planet. The time needed for the earth to make one complete turn on its axis is called the earth's day. The earth's day is 24 hours. Trainee/pupil must understand that the earth gets it light from the Sun. Because the Sun is shaped like a ball only one half can be lighted at one time. When one half is lighted by the Sun the other half is in darkness. The half that is turned toward the Sun has day light, or day time while the half that is tuned away from the Sun is in darkness or has night time. Teacher educator must say that every 24 hours, as the earth rotates once on its axis, one part of the earth will have had one period of day time and one period of night time. Teacher educator will explain why the Sun seems to rise in the east and set in the west. Because the earth turns or rotates on its axis in a counterclockewise direction (from west to east) the sun seems to move across the sky from east to west. Therefore, the Sun seems to rise in the east and set in the west.

Teacher trainee/pupil activity : 1

Teacher educator will demonstrate how the earth rotates on its axis. Instruct the trainee/pupil to push a knitting needle through a grapefruit. The knitting needle represents the axis, or imaginary line, running through the earth's north and south poles. Take an orange that represents the earth. Tilt the needle slightly and make the orange, which represents the earth spin or rotates. Another excellent analogy of the earth rotating on its axis is the merry-go-round.It turns around and around, and it has a center pole that acts as its axis.

Suggested Teaching Strategies

Teacher trainee/pupil activity : 2

Teacher educator may show to the trainee/pupil how the Sun causes day and night. Obtain a globe that rotates and will represent the planet Earth. Mark out exactly where on the globe you live in. Let a table lamps/slide projector/flashlight/torch represents the Sun. Darken the room and shine the lamp on the globe ensuring even lighting effect on it. To have the even lighting effect, the bulb os the lamp should be at the same height as the middle of the globe and the globe should be moved back and forth unit it is in the proper position. Point out that half the globe will be lighted (day time) and half the globe will be in darkness (night time) (Fig.1). Now spin or rotate the globe slowly from west to east (counterclockwise). The part of the earth where you live will go from day to night and back to day again. Also, the east will receive the light before the west.

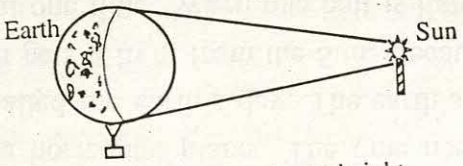


Fig. 1 : Sun causes day and night

iv) The Sun looks orange or reddish when it is rising.

Teacher educator should clarify why the Sun looks bigger when it is just rising or setting. The explanation is when the Sun is seen against buildings or other objects on the horizon, it looks bigger by comparison. When it is by itself high in the sky, it looks smaller. Why the

Sun looks orange or reddish when it is rising or setting? The teacher educator must explain that this phenomenon happens because rays of red light can pass through the ticker part of the earth's atmosphere much more easily than rays of blue light. The blue rays in sunlight can not get through greater distance of air, consequently reflected and scattered by the dust particles in the air. The reflection and scattering of the blue light by the dust particles is what makes the sky appears blue. Therefore, the sunlight now has less blue in it, so the Sun looks orange or reddish. when the Sun is high in the sky, all the rays of light can get through this shorter distance of air, so the Sun looks white.

Teacher trainee/pupil activity : 3

Teacher trainee/pupil may discover why the Sun is red at sunrise and sunset. Teacher educator should ask them to draw a diagram of the Sun and the earth at noon and Sun and the earth at noon and sunset (Fig. 2). The Sun's rays must travel a greater distance through the thicker part of the atmosphere when the Sun is low on the horizon than when the Sun is overhead. The red rays in the sunlight travel through the atmosphere in either case, but the blue rays are scattered making the Sun appear to be orange or reddish.

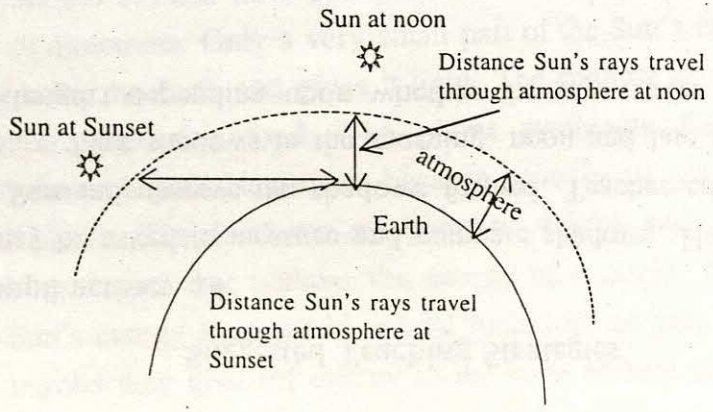


Fig. 2. Why the sun appears red or orange at sunrise and sunset

Suggested Teaching Strategies

Teacher trainee/pupil activity : 4

Trainee/pupil may be asked to measure and compare shadows. Have the pupils stand with their backs to the Sun and observe the shadows formed. Teacher educator may ask them to measure and compare these shadows in the morning, noon and late after noon. Ask them to note the different lengths depending upon whether the rays strike the body at a slant or vertically.

Minor concept(s)

v) Sun causes year and seasons on earth

Teacher educator may keep the trainee/pupil aware of other effects of Sun on earth such as: (1) The Sun causes the year on earth. Teacher educator will explain that the time needed or the earth to make one complete turn or revolution, around the Sun is called the earth's year. The earth's year is 365 1/4 days, (ii) The Sun causes the seasons on earth. The earth's axis is titled at an angle of 23½ degrees and its always pointed towards polaris, the north star. Because of this tilt and because of the earth's revolution around the Sun, the earth has different seasons of the year. When the northern hemisphere is titled toward the Sun, the northern hemisphere has summer. Summer begins on June 21. In the summer the Sun's rays are shining directly upon the northern hemisphere. The stronger, direct rays cover a smaller amount of the earth's surface, and the surface becomes quite hot. Because of the tilt of the earth's axis, the northern hemisphere also gets more day light than darkness in the summer, so days are longer than the nights. When it is summer in the northern hemisphere, the north pole has day light all 24 hours. When the northern hemisphere is titled away from the Sun, the northern hemisphere has winter. Winter begins on December 22. In the winter, the Sun's rays are shining at a slant upon the northern hemisphere. The weaker, slanted rays now cover a

large amount of the earth's surface, and the surface is not heated as much. Because of the tilt of the earth's axis the northern hemisphere gets more darkness than daylight in the winter, so the nights are longer than the days. Longer lights mean that the northern hemisphere gets the Sun's rays for a shorter time, which also helps the northern hemisphere become much colder in the winter. when it is winter in the northern hemisphere, the north pole is the darkness all 24 hours. When it is summer in the northern hemisphere, the southern hemisphere is titled away from the Sun and the southern hemisphere has winter. When it is winter in the northern hemisphere, the southern hemisphere is titled toward the Sun and the southern hemisphere has summer. In the spring and fall, the earth is tilted neither toward nor the away from the Sun. Neither hemisphere receives strong rays of sunlight. It is not summer or winter in both hemispheres, but rather somewhere between. At the same time, the days and nights are just as long. In the northern hemisphere sping beings March 21, fall begins September 23.

Minor concept(s)

vi) Sun is a source of energy for the earth

Teacher educator should explain how Sun becomes a source of energy. The Sun sends out radiant energy in all directions. Only a very small part of the Sun's energy travels to the earth. This small energy heats the earth and gives it light. The sunlight of the Sun makes it possible for green plants to synthesize food. The plants synthesize food by a process called photosynthesis. Photosynthesis is important because animals eat plants and human beings eat both animals and plants. The food we eat gives us energy and makes us grow. Teacher trainee/pupil must remember that without the energy of sunlight, the earth would be frozen and lifeless. The Sun's energy is stored in natural fuels such as gas, oil, coal and wood. When natural fuels are burned they give off energy in the form of heat and light - the same energy that originally came from the Sun and was stored in the plants by photosynthesis.

	Suggested Teaching Strategies
vii) Sun causes the weather	Teacher educator will explain how the Sun causes the weather. The Sun does not heat every part of the earth equally. This unequal heating causes movements of great masses of air. Heat of the Sun converts some of the water on earth into a gas called water vapour. When the warm air masses meeting cold air masses precipitation occurs. Thus the Sun is responsible for the different kinds and changes in weather throughout the earth.
Major concept(s) Nature of the moon **Minor concept(s)** i) Moon has no air, water, river or oceans ii) The temperature on the moon varies iii) There are mountains on the moon	Teacher educator may facilitate understanding of the nature of satellite i.e. moon that revolves around the earth. The moon is a very large ball of rocky material that revolves around the earth. It is about 3500 kilometers in diameter. Its size is about one forth of the diameter of the earth. The moon weighs about one eightieth as much as the earth. Moon's pull of gravity is about one sixth of that of the earth. Supposing, a broad jumper who can jump 12 meters (39 ft) on earth, will jump 72 meters (234 ft). Teacher educator will explain that the moon has no atmosphere. Without air these is no wind and sound can not travel, so no sounds can be heart on the moon. The moon has no water, or water vapour, no lakes, rivers or oceans and no clouds or weather. The temperature on the surface of the moon varies greatly such as during the day it may be as high as 104° Celsius and at night it may be as low as 70° below zero Celsius. Trainee/pupil must know that the surface of the moon is made up of smooth plains, jagged mountains and craters. There are many mountain ranges on the moon. Some of the mountains are more than 7500 meters (25,000 ft) high. The moon's surface is also covered with many cracks, called rills. They are about 1 kilometer wide and of unknown depth. Some rills are crooked.

Major concept(s)

Motion of the moon around the earth

Minor concept(s)

i) Moon travels around the earth in a orbit
ii) Moon keeps revolving around the earth because of two conditions
iii) Moon rotates on its axis.
iv) Moon seems to rise in the east and set in the west.
v) Moon looks yellow or even orange when it is rising and setting.
vi) Moon looks white

Suggested Teaching Strategies

Trainee/pupil must be given enough knowledge about motion of the moon around the earth. The moon travels around the earth in a path or orbit, that is shaped like an ellipse. Teacher/educator must tell the trainees that the moon moves or revolves around the earth in a counter clockwise direction (from west to east), which is the same direction as the earth revolves around the Sun. The moon is about 3,84,000 kilometers (240,000 miles) from earth. The moon keeps revolving around the earth because two conditions such as earth's pull of gravity on the moon and inertia of moon are affecting the moon at the same time. Both inertia and gravity affect the moon at the same and in such a way that the moon travels neither straight into space nor towards the earth, but around the earth. The moon revolves around the earth at a speed of about 3500 kilometers. The time needed for the moon to revolve once around the earth is called the lunar month. It takes 29½ days as the time for one lunar month. It rises about 50 minutes later each day. Trainees/pupil must know that the moon rotates on its axis in a counterclockwise direction (from west to east). It takes the moon just as long to rotate on its axis as it does to revolve once around the earth. The moon's rotation time means that the moon's day is just as long as its month. Thus, the moon has about two weeks of day light at on time followed by about two weeks of night time at one time. Because the earth rotates in a counter-clockwise direction (from west to east). the moon seems to rise in the east, move across the sky, and set in the west. The phenomenon of moon looks yellow or orange when it is rising or setting, as with the Sun, happens because rays of red light can pass through the thicker part of the earth's atmosphere much more easily than rays of blue light. Trainee/pupil must be told why moon looks white. When the moon is high in the sky, all the rays of light can get through this shorter distance of air, and thus the moon looks white.

Suggested Teaching Strategies

Teacher/trainee/pupil activity : 1

Teacher educator will help the trainee/pupil to compare the size and distance of the moon and earth. Ask the trainee/pupil to make two balls of clay, one 10 centimeters (4 inch) in diameter and the other 2½ centimeters (1 inch) in diameter. These two balls can be kept either 384 centimeters 240 inch apart. Teacher educator will point out that this will give a relative idea of the size of the noon and its distance from the earth. If 1 centimeter equals 1000 kilometers (or 1 inch equals 1000 miles, then the 384 centimeters (or 240 inch) will indicate the distance of the moon from the earth. Explain that the moon seems so small to us, even though it is one fourth diameter of the earth, because it is so far away from the earth.

Teacher trainee/pupil activity : 2

Trainee/pupil may be asked to observe the nature of the moon and explore the characteristics of the moon. When the moon is full, have the trainee/pupil observe the moon through a telescope or powerful magnifying glass. Let them try to find the more important craters, plains and mountains and help them to identify them by consulting a map of the moon. Teacher educator may discuss the prominent features - moon's pull of gravity, its temperature and its lack of atmosphere and water, results into the absence of sound and weather.

Major concept(s)

Phases of the moon

Teacher educator will have to explain in detail the phases of moon. Trainee/pupil must be knowing that the moon does not give off light, but it shines because it reflects the light of the Sun. The side of the moon that faces the Sun is always brightly lighted, but the side that is turned away from the Sun is in darkness. Teacher educator should explain that the lighted side of the moon can not be seen in the day light, except in early morning and late afternoon,

Minor concept(s)
Some phases of moon are new moon and full moon

because the Sun's light is very bright and because the earth's atmosphere scatters the sunlight in all directions. As the moon travels in its orbit around the earth, we see different amounts of the moon's lighted surface. These changes in the amount of lighted surface that we see are called the phases of the moon. During the calender lunar month when the moon makes one complete revolution around the earth in 29½ days, the moon passes through all its phases, going from completely dark to completely bright, and then back to completely dark again. Trainee/pupil must learn that when the moon is between the earth and the Sun, the dark side of the moon is turned toward the earth and we cannot see the moon at all. This phase is called the new moon. The new moon rises at sunrise and sets at sunset. Trainee/pupil should also know about half noon. About one week after the new moon, one half of the lighted side of the moon can be seen on earth. This phase is called the first quarter or half moon. The first quarter or half moon rises at noon and sets at midnight. Then about two weeks after the new moon, all of the lighted side of the moon can be seen on earth. This phase is called the full moon. Teacher educator should further explain that at full moon, the earth is between the moon and the Sun, and the moon has made one half of one complete revolution around the earth. The full moon rises at sunset and sets at sunrise. About one week after the full moon, only one half of the moon's lighted side can be seen on earth. This phase is called the last quarter or half moon. The last quarter or half moon rises at midnight and sets at noon. About one week after the last quarter, the moon has completed one revolution around the earth and is back in its original position as a new moon. The phases of the moon then start again, with the moon waxing (growing larger) until it becomes a full moon and then waning (growth smaller) until it is a new moon again.

Suggested Teaching Strategies

Teacher trainee/pupil activity : 1

Teacher educator may help the trainee/pupil to discover that the moon shines by reflected light. Obtain a tennis ball which represents the moon and a torch/flash light/table lamp which represents sunlight. Keep the ball on a table and darken the room completely. The ball cannot be seen. Then shine the torch or flash light on the ball. The ball can now be seen because the light from the torch/flashlight strikes the ball and is reflected to the eye.

Teacher trainee/pupil/activity : 2

Teacher educator has a great role in facilitating the trainee/pupil to observe and compare phases of the moon. Obtain a styrofoam ball or any cotton stuffed ball about the size of an orange or grape fruit. Insert a long thick nail into the ball to have a stem. Get a table lamp (without shade) and turn on the lamp. Instruct one trainee/pupil to kneel in front of the lighted bulb so that the trainee's/pupils head is level with the bulb. Allow other trainees/pupils sit or stand directly in front of the trainee/pupil (kneeled). Darken the room. Now holding the ball by its stem, have the trainee/pupil move the ball slowly in a counter clockwise direction around his/her head (Fig.). Here, the ball will represent the moon, the trainee's/pupil's head the earth, and the bulb the Sun. When the ball moves around the trainee's/pupil's head the other trainees/pupils will be able to see a continual complete cycle of all the phases of the moon.

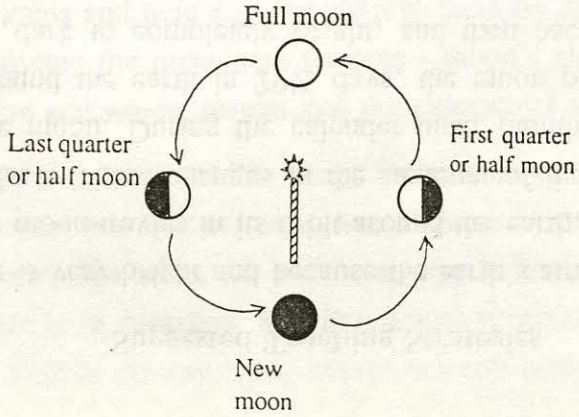


Fig. Phases of the moon

Major concept(s)

Moon causes tides

Minor concept(s)

i) Moon's weaker pull of gravity causes high tide and low tides on earth

ii) The Sun's pull of gravity on the earth also causes tides on earth

iii) The Sun and the Moon combine their pull of gravity on the Earth

iv) Knowledge of high tides and low tides can be useful

v) The Sun and Moon cause spring and neap tides

Suggested Teaching Strategies

Teacher trainees/pupils should have clear conception about tides. Teacher educator may describe in detail so as to facilitate trainees/pupils understanding. Tides are the rise and fall of the oceans caused by the moon's pull of gravity on earth. The earth has a pull of gravity on the moon and at the same time the moon has a pull of gravity on the earth. The Earth being larger than the moon, its (earth's) stronger pull of gravity helps keep the moon revolving around the earth. Tides are formed because the moon's pull of gravity on the side of the earth facing the moon makes the easily movable waters of the earth on that side bulge out toward the moon. This watery bulge is called a high tide, or flood tide. At the same time another high tide is formed on the opposite side of the earth. This tide is formed because the moon not only pulls on the earth's waters nearest it, but also pulls hard on the solid part of the earth. Because this tide is on the opposite and farthest side of the earth, where the moon's pull of gravity is weakest, away from the moon, it is called the opposite tide. The water that is drawn in to make bulges at these two points on earth comes from the remaining water at the opposite two points on earth. The water at the opposite two points now flattens out and forms lower levels. These lower levels are called low tides. Trainee/pupil must know that because the earth rotates on its axis once every 24 hours, the earth has two high tides and two low tides every 24 hours at different points of the earth. The tide rises for about 6 hours; then it falls or ebbs for about 6 hours. The Sun's pull of gravity on the earth also causes tides on earth.

Because the Sun is so much farther away from the earth, it (Sun) produces tides that are a little less than half as big as the tides produced by the moon. When the Sun is in line with the moon, very high and low tides are formed. These tides occur because the Sun and the moon combine their pull of gravity on the earth. The Sun and moon are in line with each other twice a month, at new moon and at full moon. These very high and very low tides are called

Major concept(s)

Eclipses occur at new moon as well as at full moon

Minor concept(s)

i) In new moon, moon passes between the earth and the Sun

Suggested Teaching Strategies

spring tides. Trainees/pupils must be told also about neap tides. When the Sun and moon at right angles to each other, tides that are not as high or as low as usual are formed. These tides are formed because the Sun's pull of gravity and the moon's pull of gravity are now working against each other. The Sun and moon are at right angles to each other twice a month, at first quarter and at last quarter. These smaller high and low tides are called neap tides. It is a fact that the rise in tides differs at different parts of the earth, depending upon the kind of shoreline and ocean floor found at each part.

Teacher educator must make the teacher trainees/pupils aware of usefulness of knowing when the tides will be high and low: e.g. i) ships arrive and leave only at high tide when the channel is deep enough to allow the ships to come and go safely, ii) ships like to leave port when the tide is going out so that they so not have to fight a tide that is coming in and (iii) people like to go swimming at high tide rather than at low tide.

Teacher trainees/pupils should have a clear understanding of eclipses. Teacher educator may explain the phenomenon of eclipses. As the Sun shines on the earth and the moon, both throw a long shadow into space. The earth's shadow is about 1,400,000 kilometers long while the moon's shadow is about 3,84,000 kilometers long.At certain times, when there is a new moon, the moon passes between the earth and the Sun is such a way that people on earth can not see the Sun. This phenomenon is called an eclipse of the Sun or a solar eclipse. In a solar eclipse the moon's shadow falls on the earth. The shadow of the moon has two parts: i) There is a cone-shaped inner part, called the umbra which is completely dark. There is also a broader outer part, called the penumbra, in which the light is only partially blocked. Teacher educators

ii) In solar eclipse moon's shadow falls on the earth

iii) Total eclipse of the Sun occurs

iv) In full moon, the earth passes between the Sun and the moon

v) Another kind of solar eclipse is annular or ring eclipse

will explain that the tip of the Umbra only covers a very small part of the earth's surface so that only this small part of the earth's surface is in complete shadow or darkness. People who are inside the umbra see the Sun become completely covered and blotted out from view. When the Sun's light is completely cut off, we say that a total eclipse of the sun has taken place. At any given spot on earth, a total eclipse lasts about 8 minutes. During a total eclipse, the Sun's corona can be seen. Trainees/pupils also understand that the penumbra covers a much larger part of the earth's surface. People who are inside the penumbra see only part of the Sun covered and blotted out from view. When the Sun's view is only partially cut off, we say a partial eclipse of the Sun has taken place. Sometimes, especially if the moon is near apogee and the moon is in the right position to produce a solar eclipse the moon's umbra may be too short to reach the earth's surface. When this phenomenon happens, the Sun is still eclipsed, but not completely, it shows a thin ring of light around the edges. This kind of solar eclipse is called an annular or ring eclipse. It is to be said that total eclipses of the Sun do not happen very often. For a total eclipse of the Sun, the moon must be in an exact line between the Sun and the earth when the moon reaches the new moon phase.

Teacher educator will explain that sometimes the earth passes between the Sun and the moon in such a way that the earth cuts off the sunlight that the moon reflects and the moon can not be seen. This phenomenon is called an eclipse of the moon or a lunar eclipse. An eclipse of the moon occurs only when there is a full moon, where the earth is between the moon and the Sun. In a lunar eclipse the earth's shadow falls on the moon. The moon passes quite often through the earth's rather large penumbra so that a partial eclipse of the moon happens quite often. Because the moon's orbit is titled, the moon does not pass through the earth's umbra very often so that a total eclipse of the moon is quite rare.

Suggested Teaching Strategies

Teacher trainee/pupil activity : 1

Teacher educator may help the trainees/pupil to compare solar and lunar eclipses. Let a table lamp (with the shade removed)/ a slide projector/torch represent the Sun. Get a globe of the earth and position the globe and light source so that the light falls evenly on the globe when the room is darkened. Obtain a tennis ball that represents the moon. Hold the tennis ball between the "Sun" and the "earth" so that a shadow falls on the "earth" (Fig.1). The ball may have to be moved back and forth until a sharp shadow forms on the globe. Observer on earth in this shadow would see a solar eclipse.

The teacher educator may show a lunar eclipse by holding the tennis ball or "moon" on the far side of the "earth" or globe so that the "earth" or globe is between the "Sun" or table lamp and the "moon" or tennis ball. Move the tennis ball back and forth until the "moon" or ball is completely within the earth's or globe's shadow, forming a lunar eclipse

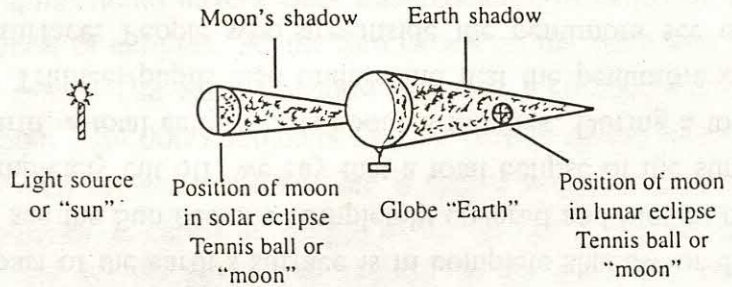
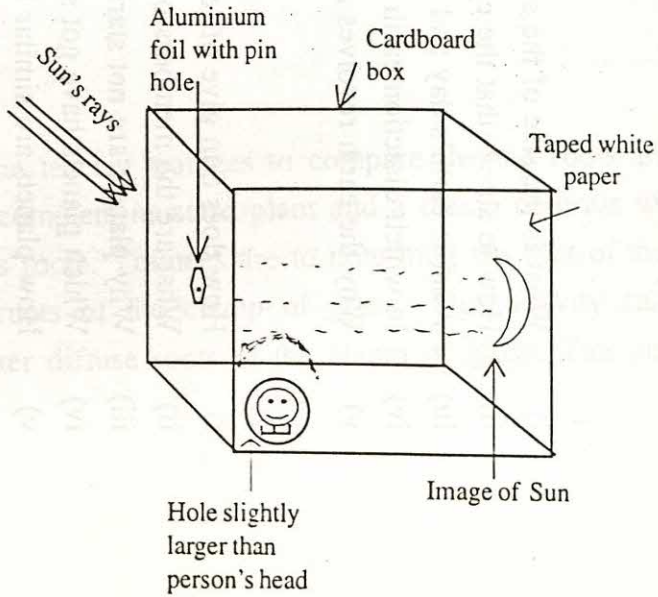


Fig. 1 : Solar and lunar eclipse

Teacher trainee/pupil activity : 2

Teacher educator may help the teacher trainee/pupil how to watch a solar eclipse. Ask the teacher trainee to get a long rectangular cardboard carton from the market. Tell the trainee to cut a hole a little larger than the size of his/her head on one long side of the carton. Tape a white paper to one end of the cartoon. At the other end of the carton cut a small hole 2½ centimeters (1 inch) square as high as possible and near the long side opposite the side where you cut a hole for your head to enter. Tape a aluminum foil over the hole, then make a pin hole in the center of the aluminum foil. Close all sides of the cardboard carton and tape them securely together to keep out the light.

Now stand with your back to the Sun, put your head into the carton and bend forward until light from the Sun enters the pinhole and forms an image on the white paper (Fig. 2). Instruct the trainees/pupils that at no time should they look directly at the Sun because it will damage their eye sight permanently.



The teacher educator may evaluate the trainees/pupils through the following kinds of evaluation instruments. The activities given here are only suggestive. Teacher trainee may design his/her own evaluation instruments or methods.

1.

i) What is the size of the sun and the earth ?

ii) How to show that the earth is round ?

iii) What is earth's day and year ?

iv) In which direction earth revolves around the Sun?

v) Why the earth revolves around the Sun ?

2.

i) How does Sun give off energy or light ?

ii) What are the members of the solar system ?

iii) Why planets are not stars ?

iv) Which planets have got satellites or moons that revolve around them ?

v) How planets are similar to each other ?

vi) How the planets are different from each other ?

vii) Why the planets revolve around the Sun ?

3.

i) How does Sun cause day and night on earth ?

ii) Why does Sun seem to arise in the east and set in the west ?

iii) Why Sun's energy is important for the process photosynthesis ?

iv) How does Sun's energy is stored in natural fuels ?

4.

i) What is the size and distance of the moon and the earth ?

ii) What are the prominent features of the moon ?

iii) Why does the moon revolve around the earth ?

iv) How many days does the moon take to go from one full moon to the next?

v) What is new moon and full moon?

vi) When does high tides occur ?

vii) What is the utility of knowledge of tides ?

viii) How could one observe solar eclipse ?

FUNCTIONS OF THE PARTS OF A FLOWERING PLANT

Major Concept(s)

A flowering plant has several parts

i) Roots are part of the plant that grows downward into the ground

Minor concept(s)

i) Root system mainly consists of the tap root system and diffuse root system

Suggested Teaching Strategies

The roots are the part of the plant that grows downward into the ground. Teacher educator will give definition of root and explain that when a seed begins to grow, a root grows rapidly which is called primary root. Then the roots keep branching and rebranching forming a root system. Secondary roots branch out from primary root. There are two main kinds of root systems i.e. the tap root system and the diffuse root system. In the former, the primary root grows until it is the largest root in the root system. This large root is called the taproot e.g. carrots. In the diffuse root system, the primary root lives only for a short time. The secondary roots then continue to grow as a cluster at the base of the stem. These secondary roots are called fibrous roots e.g. cactus, beans, corns and grasses.

Teacher trainee/ pupil activity

Teacher educator will instruct the teacher trainees to compare the tap roots and diffuse roots. Trainees are to dig up a complete mustard plant and a clamp of grass with roots, and gently wash the soil from its roots. Trainees are to note long tap root of the mustard and the many shorter diffuse roots of the clamp of grass. This activity can also be performed by pupils many shorter diffuse roots of the clamp of grass. This activity can also be performed by pupils

Minor concept(s)	Suggested Teaching Strategies
ii) There are different kinds of roots serving a variety of purposes	ii) Teacher educator should discuss different types of roots with trainees. Some tap roots store food for the plant and become large, called fleshly tap roots e.g. beets, carrots and radishes. Some fibrous roots also store food for plant and become large called fleshly fibrous roots e.g., sweet potatoes. In some plants, roots grow from the stems or leaves of the plant - such roots are called adventitious roots. Examples are : i) Tomato and cucumber form adventitious roots when their stems touch the ground, ii) the leaves of begonia form adventitious roots when placed in the soil. Some plants produce roots from their stems above the ground, such adventitious roots are called prop roots e.g. corn plant. Climbing plants such as poison ivy and tropical orchids produce roots from their stems which are adventitious roots, called aerial roots. **Teacher trainees /pupils activity** Trainees and pupils both can make collection of actual samples (or pictures wherever the actual samples are unavailable) of fleshly roots, adventitous roots, proproots and aerial roots. They will observe the nature of structure, size, shape colour and position of these samples. Then, they need to draw and label and classify each example. Teacher educator may help them in identifying and classifying the samples.
iii) Root exhibits typical structures	iii) Teacher educator must explain the structure of root. Trainees/pupils may be asked to bring the actual root samples and observe them carefully. A short distance behind the tip of each root are many tiny fuzzy root hairs. All the roots exhibit at their tips the root caps.
iv) Roots help plant in many ways	

Major concept(s)	Suggested Teaching Strategies
Roots carry out various processes the plant need to live	iv) Teacher educators must explain the trainees to a variety of functions of different groups of roots of several plants. Such functions are : a) The roots absorb water and minerals from soil and conduct them to the stem and finally into the leaves b) It holds the plant firmly in the ground c) Some roots such as beet, carrot, sweet potato and dahlia, help store food for the plant d) Some roots such as sweet potato and dahlia can regenerate new plants e) Roots play a vital role in adapting to the needs of the plant and conditions of the environment f) Roots prevent soil erosion **Trainees/pupils activity** Teacher educator may demonstrate the absorption of water and minerals by roots. Trainees can collect tomato plant (or bean, mustard, radish) with its roots and gently wash the soil from its roots. Place the roots in a glass jar containing water that has been coloured deep red with food coloring. Teacher educator will explain that within few hours or by the next day, the veins of tomato leaves will be colored red because the water and dissolved food colouring will have been absorbed by the roots and conducted up to the leaves.

	Suggested Teaching Strategies
Minor concept(s) Uses of roots in various purposes	i) Teacher educator will brief the trainees the uses of different roots such as carrot, turnip, beet, sweet potato and radish which are used for food ginger for medicine and making candy and roots of yellow wood used to make dyes.
Major concept(s) Stem forms part of the plant between the roots and the leaves	**Teacher trainees activity :** Trainees should collect roots and drawing and labelling them, classifying them according to uses and describe the purpose for which the roots and used.
Minor concept(s) i) Stems are of two basic kinds : monocotyledon stems and dicotyledon stems ii) Stems can be grouped as aerial stem and underground stem	i) Teacher educator will define two basic kinds of stems. A plant with a monocotyledon stem grows from a seed with only one cotyledon (seed leaf) in it. Monocotyledon plants can be recognised by their smooth-edged, narrow, parallel-veined leaves. Examples: Orchids, rice, grasses, corn, lilies, palm plants etc. Seed with two cotyledons or seed leaves in it give rise a plant with a dicotyledon stem. Dicotyledon plants are identified by their broad, irregularly shaped, spread-veined leaves. Examples: Soyabean, bean, rose, tomato, mustard, pea, geranium plants etc. **Teacher trainees/pupils activity** Make a collection of actual plants (or pictures where actual plants are unavailable) and classify each example of plants as:

Suggested Teaching Strategies

Monocotyledon plants		Dicotyledon plants	
a) grasses	d)	a) pea	d)
b)	e)	b)	e)
c)	f)	c)	f)

Teacher educator will explain that stems are also classified as herbaceous stems (soft and green no woody tissues such as beans, peas, tomatoes, corn, grasses) and woody stems (brown and hard having woody tissue e.g. mango, neem, i.e. mostly stems of the trees and shrubs)

ii) Teacher educator has to differentiate between aerial stem and underground stem so as to facilitate the trainee's understanding. Aerial stem grows above the ground. It is of four types; (a) shortened stems (e.g. carrot), (b) creeping stems-stolons or runners (e.g. grass, strawberry), (c) climbing stems (e.g. sweet potato, morning glory), d) erect stems (e.g. mango, holy basil (Tulasi, sunflower)

Trainees are to understand that underground stem grows below the ground. It comprises of 4 groups such as: a) rhizomes (rhizomes of the iris, lily of the valley), b) tuber i.e. enlarged tip of rhizomes (e.g., white potato). Teacher educator will explain that 'eyes' of the potato are really buds from which new growth begins c) bulb is made up of a stem shortened to the size of a disk, surrounded by thick, fleshy, scale like leaves (examples of bulbs: onion, daffodil, tulip, (d) corm is a stem surrounded by thin, scale like leaves (Examples of corm: gladiolus)

Minor concept(s)

iii) Woody (dicotyledon) stem has various external structures

Major concept(s)

Stems carry out various processes the plants need to live.

Suggested Teaching Strategies

Teacher trainees/pupil activity

Trainees/pupils can collect actual stems (or pictures wherever the actual stems are unavailable) that grow above and below the ground. They can classify the stems as:

Aerial stems	Underground stems
1)	1)
2)	2)
3)	3)

Trainees/pupils will draw and/label each of the collected stems.

iii) Teacher educator may help the trainees by taking a field trip to identify the external structures on a twig of a woody (dicotyledon) plant. Twig of a tree has buds on it. Each bud is a place on the twig where a new stem, leaves and flowers can grow. Most twigs have a terminal bud at their tip. Along the sides of the twig are lateral buds, from which branches may grow. Node is a point on the stem where leaves or branches are produced by the stem. Some twigs have thorns which help in identifying the plant. A dicotyledon herbaceous stem has a thin skin called an epidermis and a monocotyledon herbaceous stem has a hard outer covering called a rind.

Teacher educator will discuss elaborately with the trainees the essential processes the stems carry out for the existence of plant's life. The essential functions of stems are (1) stems conduct water and dissolved minerals from the roots to the leaves, (2) stems

	Suggested Teaching Strategies
Minor concepts i) Functions of stem are vital to plant's life	transport food from the site of synthesis i.e. leaves downward to the roots, (3) stem produces and holds the leaves so that they receive sunlight, (4) stems play crucial role in supporting the plant and keeping it erect position, (5) green colored stem contributes to food synthesis, (6) stems also provide storage space for storing food e.g. potato (7) aerial stems like strawberry, coleus can regenerate new young plants, (8) underground stems mostly posses capability of growing new plants. Teacher trainees/ pupil's activity Teacher educator may arrange a field trip so that trainees find opportunity to observe and understand how stems support the rest of the plant and how the trunk and branches of a tree playing vital role in displaying leaves to receive sunlight. Teacher educator may help to perform the following activity to demonstrate that the stem conducts water to all parts of the plant. Trainees will obtain a stalk of celery with leaves and place it in a glass jar filled with water, that has been coloured a deep red with food coloring. About 1 inch of the bottom of the stalk is excised off while the stalk is still under water. Allow the stalk to stand few hours to overnight. Trainees/pupils can note that the colored water has moved up the stalk and into the leaves. Now remove the stalk from the colored water and cut off a section of stalk from the bottom. Hollow tubes in the stem take on red color.
ii) Stems serve versatile purposes	Teacher educator may highlight the versatile nature of stem usage. Trainees/pupils understanding of stem uses may be facilitated by teacher educators. The major uses of stems are: (i) celery, asparagus and potato are used for food, (2) Juice of sugarcane

constitutes a potential soothing drink although used for producing sugar, (3) cinnamon bark is used as spice, (4) rubber is made from the sap/latex of the rubber tree, (5) linen is prepared from stem of the flax, (6) malarial drug quinine is prepared from cinchona bark, (7) ceough syrups is prepared from the bark of the cherry tree, (8) camphor comes from the laurel tree, (9) ropes and other string are prepared from the fibers of hemp and other plants like jute and cotton (10) turpentine from the pine tree is used in paint and varnish, (11) the wood of trees is used for making lumber, furniture, paper, telegraph and telephone poles, parts of machine, and wooden boxes, baskets, wooden caskets and barrels. Rural people also use wood for heating their houses and cooking their food

Teacher trainees/pupil activity : Teacher educator may ask the trainees to make collection of actual stems and picture of stems. They can be asked to classify the stems according to their uses, label each stem and describe the purpose for which the stem is used.

Major concept(s) 1. Leaves of flowering plants carry out important processes Minor concept(s) i) Leaves are of different kinds and shapes	Suggested Teaching Strategies Teacher educator may explain parts of a leaf, kinds and shapes of leaves. A leaf has two parts i.e. the blade and the petiole. The blade is the thin, flat, green part of the leaf and the petiole is the stalk of the leaf. Leaf is attached at a node on the stem. The blade of the leaf has veins in it and arranged in three patterns: Palmate (e.g. geranium), pinnate (e.g. willow) and parallel patterns (e.g. Lily, grasses). Teacher educator may explain that leaves with parallel veins are long and thin, pinnate veined leaves are shorter and wider and leaves with palmate veins are broad. Different kinds of leaves edges such as smooth of magnolia, toothed edge of elm leaves and, lobes or finger-like projections of maple leaves are to be discussed in details with actual leaves or picture of leaves. Teacher educator may help the trainees to know the differences between sample leaf and compound leaf. When the blade of a leaf is all in one piece called a simple leaf (e.g. cotton, rice, apple). If the blade of the leaf has three or more separate parts, called leaflets, the leaf is called compound leaf (examples: clover, pea, rose). Teacher trainees/pupils activity Teacher educator may arrange a field trip which help the trainees to collect a large variety of leaves to examine their parts, similarities and differences. Trainees/pupils should observe sizes, shapes, edges and different kinds of veins present in leaves. Teacher educator may help the trainees in distinguishing between simple and compound leaves. Trainees are asked to preserve the leaves and arrange the leaves in note books as simple leaves and compound leaves.

	Suggested Teaching Strategies
ii) The main function of the leaf is to synthesize food for the plant iii) Leaf has minute openings called stomata iv) Leaf contains green material called chlorophyll v) Green leaves need CO_2 for photosynthesis vi) Chlorophyll in the leaf uses energy of sunlight for photosynthesis vii) Oxygen gas is a waste product of photosynthesis viii) Leaves produce starch during photosynthesis	Teacher educator will explain the essential process i.e. photosynthesis in detail. Trainees/pupils will understand that only green plants are able to make their own food. Leaves contain green material called chlorophyll. Green colour of the leaf is imparted by chlorophyll. Chlorophyll also makes the leaf possible to synthesize food. The leaf uses two raw materials to make food: water and carbondioxide. The water comes from the ground conducted into the roots, stem and finally into the leaf. The carbon dioxide gas in the air passes through tiny openings in the leaf called stomata into the leaf. The chlorophyll transduces the energy of sunlight, making the leaf possible for the carbon dioxide and water to combine and form a sugar, called glucose and oxygen gas. This food making in the plant is called photosynthesis (where 'photo' means 'light' and 'synthesis' means putting together). The leaf changes the sugar (glucose) to sucrose and finally to starch either immediately or soon afterward. Some of the sugar also change in the leaf into fats and proteins. The food (glucose) made by the leaf is transported in the form of transport sugar sucrose to the stem and the roots for use or for storage. Trainees or pupils could understand that oxygen gas given off into the air through stomata of the leaf is a byproduct (waste product) of photosynthesis. The following activities can be performed by teacher trainees/pupils **Teacher trainees/pupils activity** i) Teacher educator may ask the trainees to select a tender leaf. Scrap or slice a small piece of epidermis from the under side of the leaf by using a blade or sharp knife. Keep this piece of leaf on a microscope slide, add a drop of water, and cover with a

cover glass. Observe the piece of leaf under a microscope and look for the minute openings called stomata.

ii) Teacher educator may guide the trainees how to collect chlorophyll from leaves. Obtain a spinach leaf or any green leaf and boil it in water for several minutes (10 minutes or more) to break down the plant cell walls. Then place the leaf in alcohol and boil for 10 to 15 minutes. The hot alcohol will extract the chlorophyll from the green leaf.

iii) Teacher educator may demonstrate to the trainees that green leaves need carbon dioxide as one of the raw materials for photosynthesis. Trainees are asked to select a healthy growing plant and coat the top and under surface of one leaf with a thin layer of vaseline. Place the plant under full sunlight. Within few days the vaseline-coated leaf will begin to turn yellow. Teacher educator may explain the trainees that vaseline prevented carbon dioxide in the air entering the leaf's stomata and stopped the process of photosynthesis in the leaf.

iv) Teacher educator may demonstrate that green leaves need sunlight for photosynthesis. Trainees can select a healthy plant and cover one leaf completely with aluminum foil. In a few days, the leaf will turn yellow because the aluminum foil prevents sunlight from reaching the leaf. Trainees will understand that failure to receive sunlight by the leaf stops the process of photosynthesis.

v) Demonstration of starch synthesis in the leaves during photosynthesis can be performed by teacher trainees. Teacher educator may instruct the trainees to select

plant which was under full sun so that photosynthesis can take place. Pluck one of the leaves and boil it in water for several minutes to breakdown the cell walls in the leaf. Place the leaf in the alcohol and boil for 10 to 15 minutes or longer if necessary until the alcohol extracts most of the chlorophyll from the leaf. Remove the leaf and rinse it in hot water. Keep the chlorophyll free leaf on shallow saucer and dry it by blotting gently with cleansing tissue. Place a few drop of iodine on the leaf. Colourless leaf will turn dark blue or purple colour after a few minutes. Explain the trainees that blue colour is a test for starch by adding a few drops of iodine.

Major concept(s)

Plant regulates its water content through stomata in leaves

Teacher educator will define transpiration as the process in which evaporation of water from the plant takes place Tiny cells called guard cells, control the amount of water that passes out of the leaf. Teacher educator may also make it clear that transpiration takes place mostly in the leaves but other parts of the plant can allow transpiration to take place as well.

Minor concept(s)

i) The excess water passes through the stomata into the atmosphere as water vapour

ii) Leaf also helps the plant remove waste materials

Teacher-trainee's/pupil's activity

Teacher educator may demonstrate that leaves give off excess water as water vapour through stomata into air. Obtain one potted plant and another flower pot with soil, a stick of same length as the flower pot and plant combined. Insert the stick in the soil so that the top of the stick extends slightly above the plant. Cover the soil and the sides of the 2 flower pots with aluminum foil. Now place plastic bags over the plant and the stick and tie the mouth of the bags securely around the stem and stick respectively. Now place both

	Suggested Teaching Strategies
iii) Leaves can grow new plants. Example : African violet	the flower pots under full sun for a few hours. A large amount of water droplets will appear on the inside of the plastic bag covering the potted plant. Because no water droplets appeared in the control (flower pot without a plant), the water could not have come from air. Teacher educator will conclude that the water droplets could only have come from the plant itself.
iv) Leaves serve many purposes	Teacher trainees are expected to know about various uses of leaves such as: leaves are used as food. Teacher educator may give examples like cabbage, spinach, lettuce and kale are eaten by human beings. Tea leaves are used to make a beverage. Some leaves like peppermint are used for spices and flavoring. Tobacco leaves are used for smoking. People do use leaves such as palm and grass for covering roof of their houses. **Teacher/trainees/pupil activity** Trainees may make a collection of actual leaves and classify them according to their uses and name each leaf.
Major concept(s) The flower is a special part of the plant **Minor concepts** i) Most flowers have four parts	i-iv) Teacher educator may discuss flower parts taking locally available flowers like, rose, chinarose, sunflower, zinnia, marigold and aster. Flowers have four parts : sepals, petals, stamens and pistil. Teacher educators have to facilitate the trainees to understand the arrangement of these flowers parts on one large flattened part of the stalk that holds the flower called <u>receptacle</u>. At the base of brightly coloured petals, there are usually pockets or cups of a sweet liquid called nectar which attracts bees and insects. Essential parts i.e. stamens and carpels (or pistils) ensure seed formation. Trainees/pupils should be able to

	Suggested Teaching Strategies
ii) Anther produces pollen iii) Ovary of the pistil contains ovules iv) Flowers of monocotyledon plants are different from that of dicotyledon plants.	distinguish between flowers of monocotyledon and dicotyledon plants. Teacher educator may explain that monocotyledon flower have their flower parts in threes or in multiple of three, such as six or nine, while dicotyledon flowers such as rose usually have their flowers parts in fours or fives or in multiple of fours or fives.
v) Pollination is a prelude to fertilization	**Teacher trainees/pupils activity** Teacher educator may instruct the trainees to examine parts of a flower. Trainees may obtain simple flower such as lily, petunia, chinarose or sweet pea. Trainees/pupils can observe the flower stalk and its upper larger part, the receptacle. Count the number of sepals and petals. Observe the stamens surrounding the pistil in the centre of the flower. Count the number of stamens and observe the pollen on the anther. Remove the pistil with tweezers and observe stigma, style and ovary under magnifying glass. Observe the ovules with magnifying glass after cutting the ovary lengthwise with sharp blade or knife. Teacher educator may instruct the trainees/pupils to make a large drawing or diagram of the whole flower and its individual parts. Label the parts of the flower.
vi) Fertilization ensures seeds formation vii) Flowers are used for many purposes	**Teacher trainees/pupils activity :** Pupils/trainees may be instructed to observe and compare different kinds of flowers. They may note the basic difference between complete and incomplete flowers,perfect and imperfect flowers and monocotyledon and dicotyledon flowers. Teacher educator may explain the difference between these terms and pointing and identifying different whorls, missing parts and essential flower parts. Teacher educator may help the trainees to examine a composite flower like marigold or chrysanthemum, sunflower by pulling

out a ray flower (petal) and a disk flower (little tub in the centre) and examine them with magnifying glass.

v & vi) Teacher educator may explain the trainees the concept of pollination and fertilization. For production of seeds, the pollen from anther of a stamen must be travelled to the sticky sigma of the pistil-called pollination. Trainees should be aware of two types pollination i.e. self pollination and cross pollination. Trainees are to understand that the joining of the pollen grain with the egg in an ovule is called fertilization. When fertilization does take place, the ovule develops into seed. It is also to be clear that seeds are formed only if fertilization takes place, and if an ovule is not fertilized, a seed will not be formed in that ovule.

Teacher trainees/pupil's activity :

Teacher trainees are instructed to obtain flowers that have a good amount of pollen on their anther so as to observe and understand how flowers are pollinated. Trainees may blow on the anther. creating a "wind" that blows, the pollen away. They may observe or recall how bees, insects and birds travel from flower to flower looking for nectar. Trainees/pupils are to observe the shapes of flowers that are visited by bees and other insects.

Teacher educator may point out that the stamens and pistils of the flower are positioned so that when the bee or insect obtains the nectar, it must pick up some of the pollen from the stamens and at the same time rub against the pistil. Besides, when the insects or bees

travel to other flowers, they touch the pistil again and in this way they deposit some of the pollen that clings to their hairy body-facilitating fertilization to occur.

vii) Teacher educator will make the trainees/pupils aware of various uses of flowers. They may explain that flowers, because of their beauty, are used every where for decorative purposes. Cauliflower buds are used for food. Myrtle tree produces cloves which are dried flower buds. Besides, flower are used in making perfumes.

MAGNETISM

Teacher trainees will have competencies to

i) classify magnets according to their shapes

ii) clarify how two like poles attract each other and two unlike poles repel each other

iii) have idea about magnetic field of a magnet

iv) distinguish between magnetic and non-magnetic materials

v) understand that magnet can attract through non-magnetic materials

vi) clarify nature of magnetism

vii) make temporary magnets

viii) prevent loss of magnetism

ix) give examples of uses of magnets in industry, home, communication, appliances and in many toys and games

x) demonstrate different activities for magnetism

	Suggested Teaching Strategies
Major concept(s) Magnets are materials that attract certain materials **Minor concept(s)** i) Magnets are of two kinds ii) Magnets obey the law of magnetic attraction iii) Magnet works within magnetic field iv) Magnet can attract through non-magnetic materials but not through magnetic materials v) Magnetism is due to the nature and arrangement of molecules inside the magnetic material	i) Teacher educators have a role to explain many concepts on magnetism so that teacher trainees/pupils may have clear conception. Magnets are materials that will pick up or attract materials made of iron, steel, cobalt and nickel. These materials are called magnetic materials. There are two kinds of magnets : natural magnets and man-made or artificial magnets. Natural magnets are found in the ground and are called lodestones containing an iron ore i.e. magnetite having irregular shape. Manmade or artificial magnets can be prepared only from iron, steel, cobalt and nickel (magnetic materials). Artificial magnets are named according to their shapes : bar magnets, rod magnets, horseshoe magnets and U-shaped magnets. **Teacher trainee/pupil activity : 1** Teacher trainee/pupil can determine what materials a magnet will attract. Ask the trainees/pupils to collect a variety of materials such as paper clips, nails, pins, needles, coins, rubber bands, pebbles, sand and small pieces of chalk, crayon, wood, paper, glass, cloth, leather and aluminum foil. Let the trainees/pupils try to pick up or attract each object with a magnet. Trainees/pupils can put one side all those objects that are attracted by the magnet and note that these objects are all made of iron or steel or nickel or cobalt. ii) Teacher educator will explain the law of magnetic attraction. He explains that the force (push or pull) of a magnet is strongest at its ends, which are called poles. A man-made or artificial magnet has two poles: a north-seeking and a south-seeking pole. When a magnet

	Suggested Teaching Strategies
vi) There are ways of making temporary or permanent magnets vii) Magnets can lose their magnetism viii) The earth behaves as a magnet	is allowed to swing freely in space, its north-seeking pole points toward the north and its south-seeking pole points toward the south. This is the reason why the poles are called north-seeking and south-seeking. On the contrary, a natural magnet (lodestone) has many poles, but there are always just as many north seeking poles as there are south-seeking poles. Teacher educator now explains that when the poles of two magnets are brought near each other, they obey the law of magnetic attraction, which states that two unlike poles attract each other and two like poles repel each other. **Teacher trainee/pupil activity : 2** Teacher educator will help the trainees/pupils to discover that the attraction of a magnet is strongest at its poles. Ask the trainees/pupils to obtain iron fillings from a scientific supply house or one can make fillings by cutting up fine steel wool into very small pieces with a scissors. Now ask them to try picking up the fillings with a bar magnet, using different parts of the magnet each time. The fillings will be attracted most strongly to the poles of the magnet. Ask the trainees/ pupils to repeat the activity using horseshoe and a 'U' shaped magnet. Thus the teacher educator will explain that the force of a magnet is strongest at its poles and not in the middle. **Teacher trainee/pupil activity : 3** Trainees will discover the law of magnetic attraction. Let a bar magnet swing freely by cradling it in a piece of copper wire and connecting the wire with a string to a ruler inserted into a pile of books (Fig.1). Now, bring the north-seeking pole of another magnet near the north-seeking pole of the suspended magnet. Bring the two south-seeking poles

together. Now bring the north-seeking pole of the magnet in your hand near the south-seeking pole of the suspended magnet. Point out to the trainee to note that like poles repel each other and unlike poles attract each other.

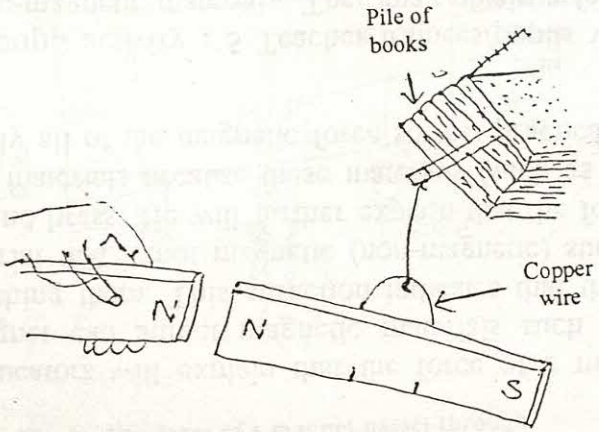


Fig. 1 : Like poles repel each other, and unlike poles attract each other

iii) Teacher educator will tell the trainees/pupils that the space around a magnet also can act like a magnet. This space, around which the force of a magnet acts or is felt, is called the magnetic field. If iron fillings or pieces of steel wool are sprinkled around a magnet, the fillings arrange themselves into a pattern of lines. These lines are called lines of forces indicating where the magnetic field is located and how it is arranged. There are more lines of force bunched closely together at the ends (poles) of the magnet where the magnetic force is strongest, than at the middle of the magnet.

Teacher trainee/pupil activity : 4

Teacher educator may show magnetic field and lines of force. Place a sheet of window glass over a bar magnet. Then sprinkle iron fillings or tiny pieces of steel wool all over the window glass and tap the window glass gently. Observe that the fillings or pieces of steel wool will rearrange themselves to form a definite pattern, showing the magnetic field and the lines of force located within the field. Point out that the lines of force are concentrated at the poles. Trainee could repeat this activity using two bar magnets placing unlike poles near each other and placing like poles near each other. Note the lines of force seem to attract each other between unlike poles and how lines of force show the repulsion between like poles.

iv) Teacher educators will explain that the force of a magnet can pass through many materials. A magnet can attract magnetic materials such as iron, steel, cobalt, nickel without even touching them. This attraction indicates that the force of a magnet can pass through any material that is not magnetic (non-magnetic) such as air, paper, wood, cloth, aluminum, glass and brass. He will further explain that the force of a magnet does not pass through magnetic materials because these materials (such as iron, steel, nickel and cobalt) hold or keep nearly all of the magnetic force so that practically none of the force can pass through.

Teacher trainee/pupil activity : 5 Teacher trainees/pupils will discover that magnets can attract through non-magnetic materials. They may obtain a few books, a cardboard/sheet of glass, aluminum foil, wood and cloth, some thumb tacks and a bar magnet. Place a cardboard on two piles of books set a short distance apart. Keep some thumb tacks on the cardboard and move or slide a bar magnet along the underside of the cardboard (Fig.2). Observe that the magnet will attract the tacks and make them move. Ask the trainees/pupils to repeat the activity using sheets of glass, wood, aluminium foil, and cloth. Now use a sheet of iron, cut from a large 'tin' can with tin snips. The tacks will not move because the

force of the magnet passes into the iron sheet making it a magnet that attracts the tacks and holds them fast. The teacher educator will explain that magnet attracts through non-magnetic materials but not through magnetic materials (such as iron sheet)

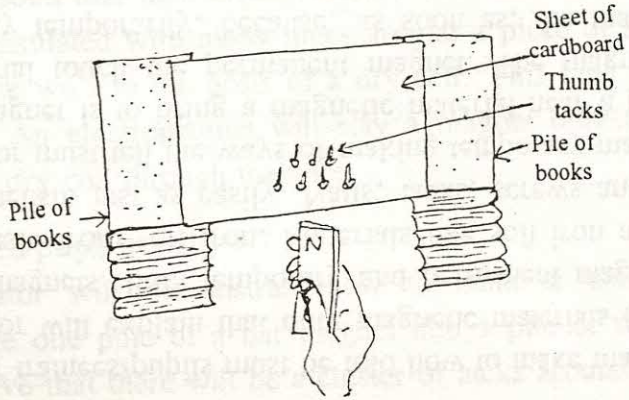


Fig. 2 : The force of a magnet passes through nonmagnetic materials

Teacher trainee/pupil activity 6

Trainees/pupils may examine a compass and discover that a compass needle is a magnet. The end of the needle that points to the north is usually coloured blue or black and is called the north-seeking pole. Teacher educator may tell them to bring the north-seeking pole of a bar magnet near the compass. They will observe that the north-seeking pole of the compus needle will be repelled while the south-seeking pole of the compass needle will be attracted. Explain that a compass needle can be used to determine the poles of an unmarked magnet.

v) Trainees/pupils must be provided adequate knowledge on magnetism. Scientists thought that magnetism in a magnetic material was due to the nature and arrangement of the molecules inside the magnetic material. They believed that every molecule in a magnetic material behaved as if it were a tiny magnet, with a north-seeking and a south-seeking pole. Today, scientists believe that the magnetism of magnetic materials is due to the spinning movement of the electrons as they revolve or travel around the nucleus in the atom. Each spinning electron acts as a tiny magnet. In atoms of magnetic materials more electrons spin in one direction than the other making each atom a tiny magnet. In atoms of non-magnetic materials half their electrons spin in one direction and half spin in the opposite direction, which cancel their magnetic effects.

vi) (a) Teacher trainees/pupils must be told how to make magnets from magnetic materials. Teacher educator will explain that only magnetic materials (iron, steel, nickel, cobalt) can be made into magnets. Both temporary and permanent magnets can be made. Temporary magnets are made from soft iron. Materials like soft iron are easy to magnetize but they lose their magnetism just as easily. Nails, tacks, screws and bolts are made of soft iron. Teacher educator must tell the ways of making temporary magnet: (i) One way of making a temporary magnet is to bring a magnetic material near a permanent magnet or have the magnetic material touch the permanent magnet. The magnetic material now becomes a magnet but only temporarily, because, as soon as, the material is taken away from the permanent magnet and its magnetic field, the material loses its magnetism. This way of making magnets is called <u>induction</u> or <u>induced magnetism</u>, ii) <u>second way of making</u> a temporary magnet is <u>to stroke</u> a piece of soft iron (such as a nail) many times with a permanent magnet, but only in one direction. Teacher educator will further explain that stroking only in one direction helps line up the domains (or molecules) in soft iron so that

all the north-seeking poles are facing one direction and all the south-seeking poles are facing the opposite direction. The soft iron is only a temporary magnet because the domains (or molecules) soon lose their arrangement, iii) A third way of making a temporary magnet is to wrap an insulated wire many times around a piece of soft iron, and then connect the bare ends of the wire to the posts of a dry cell. This kind of temporary magnet is called electromagnet. An electromagnet will stay a magnet only as long as the electric current flows from the dry cell through the wire.

Teacher trainee/pupil activity : 7

Teacher educator will demonstrate how to make a temporary magnet by induction. Immerse/plunge one pole of a bar magnet into a pile of small tacks and then lift up the magnet. Observe that there will be a cluster of tacks around the pole. Each tack becomes a magnet by induction and attracts other tacks. Point out that this induced magnetism is temporary because as soon as the bar magnet is taken away, the tacks do not attract each other any more. Hold a large iron nail quite close to one pole of a strong bar magnet. Keeping the nail and magnet in this position, dip the nail into a pile of small tacks, and then lift up the nail (Fig. 3). The nail has been magnetised by induction, without even touching the magnet, and attracts the tacks. The tacks in turn are also magnetised by induction. When the bar magnet is removed, the nail loses its magnetism and the tacks fall off.

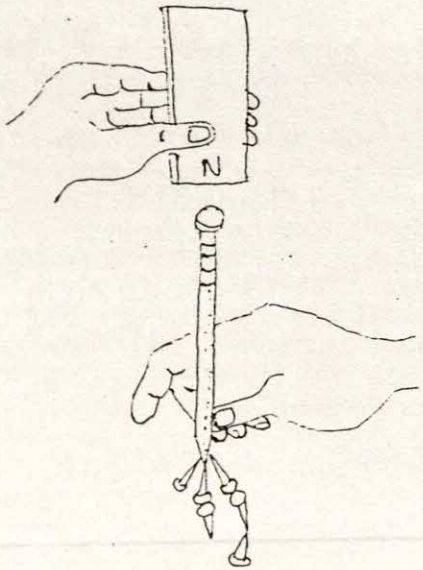


Fig. 3 : The nail attracts the tacks because of induced magnetism

Teacher trainee/pupil activity : 8 Trainee/pupil will learn how to make a temporary magnet by stoking. Teacher educator may instruct the trainee or pupil to stroke a large iron nail or spike from end to end with one pole of a strong bar magnet about 20 times. Warn them to stroke slowly and gently in one direction only (Fig. 4). Observe that the nail will become a magnet and pick up iron fillings or pieces of steel wool or tacks. Now tell them to set the nail aside for 3 to 4 days. Point out that because the nail is made up of soft iron, it will have lost most of its magnetism and it will pick up very few fillings or tacks or steel wool pieces.

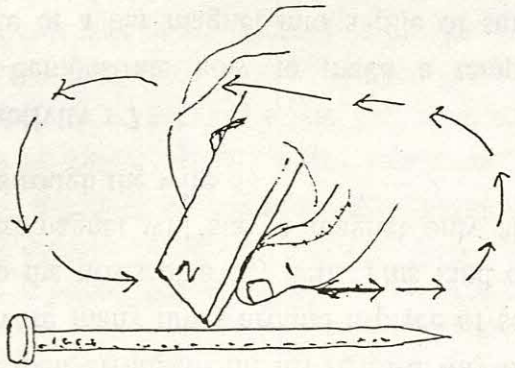


Fig. 4 : The nail becomes a temporary magnet when stroked with one pole of a bar magnet

Teacher trainee/pupil activity : 9

Teacher educator may demonstrate how to make a temporary magnet with electricity. Instruct them to obtain some insulated copper bell wire. (No.20) from electric store. Wind this wire in a coil around a large iron nail about 15 to 20 times. Remove the insulation from both ends of the wire, connect one end to a terminal of a dry cell, and touch the other end to the second terminal for a few seconds (Fig.5). The nail will now pick up tacks and other objects made of iron or steel, and is called an electromagnet. When you remove the wire from one of the terminals, the electric current stops flowing and the nail loses its magnetism

Note : Keep the wires connected to the dry cell for as short a time as possible. Otherwise the dry cell will be used up very quickly.

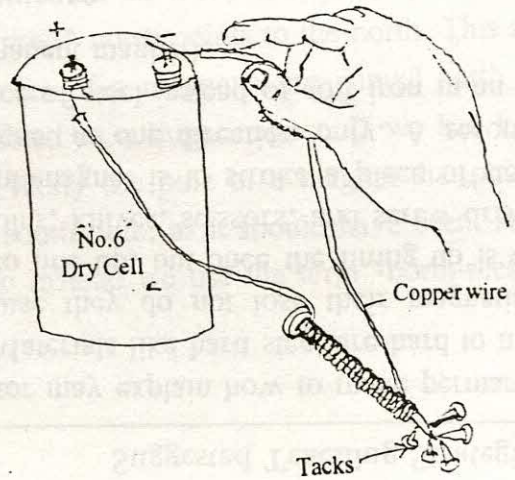


Fig. 5 : An electromagnet is a temporary magnet

vi)(b) Teacher educator may explain how to make permanent magnet. Permanent magnets are made from steel. Materials like hard steel are hard to magnetise, but their magnetism is more permanent because they do not lose their magnetism easily. Their molecules (or electrons) are harder to line up, but once the lining up is done, it is just as hard to throw them out of line. Needles, knives, scissors, and screw drivers are made of steel. One way of making a permanent magnet is to stroke a piece of steel (knitting needle) many times with a permanent magnet in one direction only. A second way of making a permanent magnet is to use a piece of steel instead of soft iron in an electromagnet (where electricity is used to make a permanent magnet).

Teacher trainee activity : 10

Teacher educator may instruct the trainee to repeat the activity 8 above using a steel knitting needle instead of an iron nail. Observe that the knitting needle retains most of its magnetism after it has been set aside for 3 to 4 days. Ask the trainees to determine the poles of this magnetized knitting needle by bringing a compass near it (see activity 6 above). Instruct the trainee to cut the magnetized knitting needle in half with cutting pliers. Each half will becomes a new magnet, with poles.

vii) Teacher trainees/pupils must be knowing that magnets do lose their magnetism. There are many ways in which magnets can be made to lose their magnetism: i) By dropping or striking them, 2) By heating them, 3) By placing the north-seeking poles of two magnets side by side or on top of each other. In each case the domains (or molecules) will be disarranged and thrown out of line and in this way neutralize each other. Teacher educator must have to aware trainees/pupils of ways of keeping magnets strong. i) One way is to put a piece of soft iron, commonly called a keeper, across the poles of a horseshoe magnet or

'U' shaped magnet, 2) A second way is to store two bar magnets so that the north seeking pole of one magnet is beside or on top of the south-seeking pole of the other magnet and then place a keeper across the poles of both magnets

viii) Teacher educator must clarify that the earth behaves as a magnet. If a magnet is suspended so that it can swing freely, the magnet will move until it is in a north-south position, with a north-seeking pole of the magnet pointing to the north. This movement occurs because the earth behaves as if it were a huge magnet, with a north magnetic pole, a south magnetic pole and a magnetic field. A compass tells us where the direction north is because it contains a magnetized needle whose north-seeking pole is affected by the earth's magnetic field and points in the direction of the north magnetic pole. Teacher educators must be aware of confusion in many trainees/pupils/persons because the pole of a free swinging magnet "marked" north points to the north. This attraction of apparently like poles occurs because the poles of a magnet were named north and south poles long before we knew that the earth acted as a huge magnet. If we had known about the earth's magnetic field first, then most likely the pole of a magnet that points to the north would originally have been called the south pole, as it should have been. As making this change now would be most confusing, so instead we use the term "north-seeking" and "south-seeking" for the poles of a magnet.

ix) Teacher educator may discuss the various uses of magnets. Magnets can be used to pick up pins and needles, to keep cabinet and refrigerator door closed, to hold the lids of cans after the can opener has removed them, and to hold pieces of paper and other objects. Magnets are used also in electric motors and generators, in compasses and in many toys and games. Electromagnets are used in telegraph and in other forms of communication such as the telephone, radio and television. It is used in industry in such devices as the motor, generator, transformer and crane. Electromagnets are found in the home in bells, buzzers, chimes, circuit breakers, some electric appliances and in many electric toys.

Teacher educator may instruct the teacher trainees to read and discuss uses of magnets and electromagnets in industry and the home.

ELECTRICITY AND ITS USE

Teacher trainees will have competencies to

1) discover how friction produces static electricity

2) differentiate between static and current electricity

3) classify materials that are conductors and non-conductors

4) state law of electrostatic attraction and repulsion

5) perform activity how electrically charged materials attract uncharged materials

6) Understand occurances like lightning and electric sparks

7) list out common phenomena of static electricity

8) make a simple electric circuit

9) make list of all appliances making use of electricity

10) understand safety rules and list out safety rules for using and handling electric appliances, wires and switches.

Suggested Teaching Strategies

Major concept(s)

There are two kinds of electricity: static and current

Minor concept(s)

i) Nature of static electricity

ii) Law of electrostatic attraction and repulsion

iii) Electrically charged materials attract uncharged materials

iv) Common occurrances of static electricity

Teacher trainees/pupils must have in depth conception of static and current electricity. Teacher educator will explain that static electricity is produced by friction. When two different materials, especially nonmetals, are rubbed together, they each attract light objects such as bits of paper and cotton thread, to them. You say that these materials have become electrically charged. The kind of electricity that has been produced in these materials does not move, and is called static, or stationary electricity. When electricity does move, it is called current electricity.

Teacher educator will explain in detail the nature of static electricity. All matter is made up of tiny particles called atoms. Inside the atom are three tinier particles : Protons, neutrons and electrons. Each proton has a positive (+) electrical charge and each electron has a negative (-) electrical charge. The neutron is neither positively nor negatively charged. It is said to be neutral. Ordinarily, there are same number of positively charged protons and negatively charged electrons in the atom. However, it is possible to remove electrons from the atoms in material by rubbing the material with another material. Trainee/pupil must understand that when two materials are rubbed together, electrons pass from one material to another. The material that loses electrons now has more positively charged (+) protons than negatively charged (-) electrons, so this material becomes positively charged. Similarly the material that gains electrons now has more negatively charged (-) electrons than positively charged (+) protons, so it becomes negatively charged. When a hard rubber rod is rubbed with wool or fur, some electrons are rubbed off the wool or fur and onto the rubber.The rubber has gained negative electrons and becomes negatively

charged while the wool or fur has lost negative electrons and now has more positive protons than negative electrons, so it becomes positively charged. But when the rubber rod is rubbed with a plastic bag, electrons are rubbed off the rubber and onto the plastic. The rubber has lost electrons, so it is now positively charged while the plastic has gained electrons, so it is now negatively charged. When a glass rod is rubbed with a piece of nylon, some of the electrons are rubbed off the glass and onto the nylon. Here, the glass has lost negative electrons and becomes positively charged while the nylon has gained negative electrons and becomes negatively charged. Materials will stay charged only as long as electrons have no way of entering or leaving the materials.

ii) Teacher educators will have to explain the law of electrostatic attraction and repulsion. Explain that when two negatively charged or positively charged materials are brought close to each other, they will repel or move away from each other. But when a positively charged material is brought close to a negatively charged material, they will both be attracted and move closer to each other. Teacher educators will explain that these behaviours can be stated as a law of electrostatic attraction and repulsion: the same kind of electrical charges will repel each other, but different kinds of electrical charges will attract each other.

Teacher trainee/pupil activity : 1 Teacher educator may help the trainee/pupil to discover that friction produces static electricity. Trainee/pupil can rub a hard rubber comb briskly with wool cloth. The comb will pick up bits of paper. Again, rub a blown-up balloon with the wool and put the balloon against the wall. Observe that the balloon will stick to the wall. In each case electrons are rubbed off the wool onto the objects, charging the objects (comb, balloon) negatively and the wool positively.

Suggested Teaching Strategies

Teacher trainee/pupil activity : 2 Trainees/pupils could discover the law of electro static attraction and repulsion. Teacher educator will instruct the trainees/pupils to blow up two balloons to the same size and suspend each balloon from a string so that they are 1 inch apart. Rub each balloon briskly with a wool cloth. The balloons will become negatively charged and repel each other (Fig. 1). Now rub a test tube or a narrow glass jar with nylon or a plastic bag and bring the jar or test tube near each of the balloons. The jar or test tube having become positively charged will attract the negatively charged balloons.

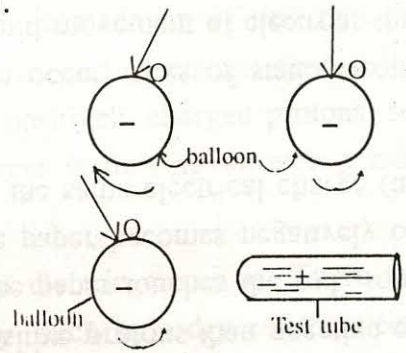


Fig.1 : Like charges repel each other, unlike charges attract each other

Teacher trainee/pupil activity : 3 Teacher trainees/pupils can investigate the effects of static electricity. Charge a balloon by rubbing it briskly with wool cloth. Now, pass the balloon over a trainee's/pupil's head. Observe that the charged balloon will cause the hair of the trainee/pupil's head to stand on end. Secondly, rub a fluorescent light tube briskly with a piece of nylon or silk in a completely darkened room. The fluorescent tube will glow faintly.

Suggested Teaching Strategies

iii) Teacher educator will explain how the materials that are either positively or negatively charged will attract materials that are not charged. Materials that are not electrically charged are said to be neutral. When a negatively charged hard rubber rod is brought close to a small piece of paper, the paper is attracted to the rod. Because (a) the negatively charged rubber rod repels electrons from the side of the paper nearest the rod. b) These electrons move to the otherside of the paper, as far away from the rod as possible. (c) The side of the paper nearest the rod is now positively charged because it has more positive protons than negative electrons, so it is attracted to the negatively charged rod. d) When the paper touches the rod, some of the excess electrons from the rod flow into the paper, and the paper becomes negatively charged too. e) The paper then drops off the rod because it now has the same electrical charge (negative) as the rod and is repelled.

iv) Teacher educator may discus common occurrances of static electricity such as: a) electric spark, b) lightning and c) thunder. The rapid movement of electrons through the air appears as a spark and is actually a flow of current electricity. Trainees/pupils must be given conception how lightning is produced. Lightning is the huge spark produced when the electrons leap suddenly from the following places: a) One charged part of a cloud to another, b) One charged cloud to another of opposite charge. c) A charged cloud to the earth, and d) The earth to a charged cloud. Teacher educator will also explain that when lightning strikes the earth, it usually strikes an object such as a tall tree that is the highest point on the earth's surface. So, it is a good idea to keep away from trees or other tall objects during a thunderstorm. Lightning rods are used to protect buildings from damage by lightning: Trainees/pupils should know that we see the lightning

first and then hear the thunder because light travels much faster than sound. Besides, teacher educator will also cite instances like combing (your) hair with a rubber cumb will charge the hair and make it stand on end. The cumb removes electrons from the hair, leaving the hair positively charged. Because, each strand of hair has the same positive charge, they all repel one another and your hair tends to stand on end.

v) Nature of current electricity

v) Teacher educators will explain the current electricity in details. The word 'electricity' is used to describe a flow of electrons. All matter is made up of tiny particles called atoms inside of which are tinier particles: protons, neutrons and electrons. Ordinarily an atom has the same number of negative charged electrons and positively charged protons, so it is electrically neutral. Scientists think that when an electric current is flowing through a material the electrons move from atom to atom inside the material.

vi) Parts of electric circuit

vi) Trainees/pupils must understand what electric circuit is. There are three parts to a simple electric circuit : a) A source of electricity, such as a dry cell or electric generator, (b) A path along which the electric current can travel, such as a copper wire and (c) An appliance that uses the electricity such as a bell or a light bulb.

vii) Some materials allow an electric current to follow and some do not allow an electric current to follow

vii) Teacher educator must distinguish between conductors and non-conductors. Trainees/pupils should be able to differentiate and understand these materials. Teacher educators will explain that some materials called conductor allow an electric current to follow through them easily while some materials that do not allow an electric current to flow through them easily are called non-conductors or insulators. Most metals are good conductors of electricity such as copper, silver,

aluminum, iron and zinc. Carbon, can also conduct electricity, although a nonmetal. When certain chemicals, known as acids, bases and salts are dissolved in water, the solutions will conduct an electric current.

viii) Sources of electricity

Examples as of insulators (non conductors) are paper, wood, glass, porcelain, cloth, dry air, rubber and many plastics. Teacher educators also have to explain that pure water itself is a non-conductor of electricity. But water will make many insulators become good conductors, when they are wet. Thus you will say that it is a good and safe practice not to touch electric appliances or wires when their hands are wet or if they are standing on a wet floor.

Teacher trainees/pupils activity : 4 Teacher educator will help the trainees how to make a simple electric circuit. Trainees may obtain a No.6 dry cell, insulated copper bell wire (No.20), a one cell flashlight bulb, and a small porcelain socket to hold the bulb from a electrical store. Set up simple electric circuit, as shown in Fig. 2 being sure to remove the insulation from the ends of the wires. Trace the flow of current through the completed circuit. Now break the circuit by disconnecting one of the wires attached to the dry cell or porcelain socket.

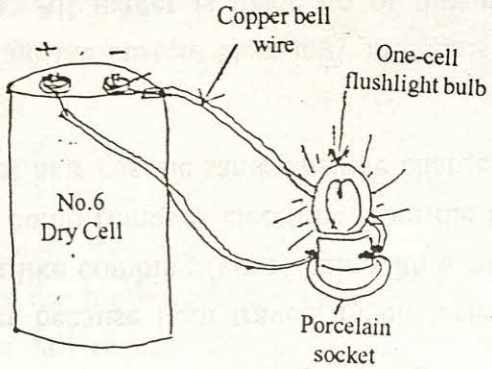


Fig. 2 : A simple electric circuit

Suggested Teaching Strategies

Teacher trainees/pupils activity : Trainees/pupils may be helped by the teacher educators in comparing conductors and non-conductors.

viii) Trainees/pupils will learn that electricity can be obtained in different ways. Electricity is a form of energy and can be produced from other forms of energy. The following forms of energy can be changed or transformed into electrical energy: a) chemical energy, using the wet cell, dry cell, and storage battery, b) mechanical energy, using the generator, c) light energy using the photoelectric cell and the solar battery and d) heat energy, using the thermo couple.

ix) Nature of dry cell

ix) The teacher educators will explain the dry cell so as to give a clear conception to the trainees/pupils. The dry cell is a more convenient form of wet cell. The materials are placed in a scaled container so that nothing can spill when the dry cell is carried or tipped. A dry cell is not really dry. The chemical inside must be kept moist. The older and more commonly used dry cell is the carbon-zinc cell having the following constituents (a) There is a zinc can which serves as a negative pole and also as a container for rest of the chemicals in the cell (b) A carbon rod in the middle of the can serves as the positive pole, c) The can is then filled with a wet paste of ammonium chloride and zinc chloride, mixed with particles of manganese dioxide and powdered carbon, d) Blotting paper soaked in ammonium chloride solution lines the inside of the zinc can to help keep the chemicals moist longer, e) Metal posts, or terminals, are on top of the can: one attached to the carbon rod, the other to one end of the can. Teacher educators will now explain that the zinc reacts with the moist ammonium chloride and accumulates electrons, becoming negatively charged. The carbon rod loses electron and becomes positively charged. When a wire is connected to the two terminals on top of the dry cell, an electric current flows from the zinc to

the carbon terminal. Teacher educator will have to tell that the newer alkaline-manganese cell lasts longer than the carbon-zinc cell. Because, it has a steel can filled with moist potassium hydroxide. The positive pole is manganese-dioxide. The negative pole is granulated zinc. Dry cells can not give large steady electric current for a long time dry. Cells are used in flash lights and portable radios and various electronic items.

x) Uses of electricity

x) Teacher educator may discuss the various uses of electricity and help the trainees to be familiar with uses of electricity: i) Electricity can be used to produce heat and light. Trainees will understand that when a conductor becomes hot enough, it will give off light. The filament of wire in a light bulb is long and thin. The filament offers so much resistance to the flow of electric current that the filament becomes hot enough to give off a bright light. ii) Electricity can be used to produce motion and power. It is used to run motors, iii) It is used to plate metals in a process called electroplating, iv) Electricity is used in many forms of communication such as telegraph, telephone, radio, television and motion pictures.

xi) Obeying safety rules for electricity

xi) Teacher educators should familiar the trainees /pupils with the following safety rules for electricity.

i) Disconnect all electrical appliances, especially heating appliances when they are not being used, ii) Never touch a switch or electrical appliance, radio or telephone when your hands are wet and when you are in the wet floor/bath tub, iii) Make sure the switch is turned off whenever you disconnect or connect an electrical appliance, iv) Do not overload your home circuit by plugging

too many appliances in one wall plug, v) Never touch a bare wire that is carrying an electric current, vi) Never poke around the back of a ridio, tape recorder or television set when these appliances are turned on, vii) Never put your finger into an open electric socket, viii) Never touch an electric cord with wet hands

Teacher trainee/pupil activity : 6

Trainee/pupil can cut a used up dry cell lengthwise in half with a saw. Examine each part and discuss its function.

Teacher trainee/pupil activity : 7

Instruct the teacher trainees/pupils to read and discuss how electricity is converted to motion, heat, light and sound in the home, school and in industry. Let the trainees/pupils make a list of all the appliances they can think of that make use of electricity.

Teacher trainee/pupil activity : 8 Trainees/pupils can make either one composite or several individual lists of safety rules for using and handling electric appliances, wires switches and fuses.

TYPES OF ROCKS AND SOIL

Teacher trainees will have the competencies to :

i) collect, observe and classify rocks

ii) examine different samples of rocks

iii) perform activity to observe how sediments settle in water to form layer

iv) examine the samples of metamorphic rocks

v) impart knowledge on how soil formation occurs

vi) compare different kinds of soil

vii) perform activity to show how fast water goes into different kinds of soil

Major concept(s)

Rock is the solid portion of the earth's crust

Minor concept(s)

i) Rocks are of three kinds
ii) Igneous rocks were formed from molten material called magma
iii) Sedimentary rocks were formed from sediments
iv) Metamorphic rocks are changed igneous and sedimentary rocks

Suggested Teaching Strategies

i) Teacher educators will explain different kinds of rocks, its formation, environmental factors responsible for formation of rocks and chemical composition of rocks. Explain that the solid part of the earth's crust is made up of great masses of hard material called rock. Trainees/pupils might be familiar with the smaller rocks and boulders which are just differently sized broken off pieces from these large masses. These different kinds of rocks can all be divided into three main groups according to the way in which they were formed. The three kinds of rocks are igneous, sedimentary, and metamorphic rocks.

ii) Trainees/pupils must learn that igneous rocks are rocks formed from hot molten material called magma in or below the earth's crust. Magma forms when the pressure below the earth's crust changes. Rock formed from magma that reached the earth's surface and then cooled is called extrusive rock. Rocks formed from magma that could not reach the earth's surface because of the rocks lying above the magma and therefore cooled below the surface, are called intrusive rocks. Examples include: i) Granite (used in road construction, buildings and monuments), Basalt (dark colored), pumice (light colored) and obsidian (black and glossy colored)

Teacher trainee/pupil activity : 1

Teacher educator may help the trainee how to collect, what to observe and how to classify rocks. Collect samples of different rocks in your community. Teacher educator may tell the sources of rocks such as river banks, road cuts, excavations for large buildings, beaches, gravel pits, quarries and mine

dumps. After the rocks have been collected, classify the rocks in groups according to similarities in colour, shape, material and other characteristics. Teacher educator may point out that the smooth and round rocks have most likely been acted upon by running water. Flat rocks are usually pieces of sedimentary rock. Crystals in the rock usually mean that the rock is igneous.

Teacher trainee/pupil activity : 2

Teacher educator may help trainees to examine igneous rocks. Trainees/ pupils must obtain samples of such igneous rocks as granite, basalt, obsidian and pumice. Observe them carefully with and without a magnifying glass. Teacher educator may point out that light coloured igneous rocks like granite, are made of mostly light minerals (quartz) and small dark minerals (mica). Dark coloured rocks like basalt are made up of dark coloured minerals as biotite or mica. Black coloured obsidian is because of magnetite. Trainees observe how pumice is spongy and full of air holes. See if the pumice will float in water. It will float if there are enough air holes in it.

iii) Trainee/pupils will understand that sedimentary rocks were formed from different sediments that accumulated for several thousand years and then were cemented tightly together. One kind of sediment that forms sedimentary rock includes such materials as sand, clay, silt, pebbles, and gravel. Streams and rivers carry these sedimentary materials to lakes or oceans where they settle to the bottom. As the sediment accumulates, layers are formed which then slowly change into solid rock. This change happens because the weight of the top layers presses the sediment in the bottom layers tightly together. At the same time, chemicals

that are already dissolved in the water now begin to deposit out again on and between the particles of sediment, fill the tiny spaces between the particles, and then cement them firmly together. Teacher educator will give examples of sand stone, shale and conglumerate as sedimentary rocks that formed in this way. Sandstone may be red, brown or yellow coloured; shale is usually grey or green but may be blue, purple or even black; conglumerate is made of pebbles and gravel that determine the colour. Limestone is another kind of sedimentary rock formed from shells and skeletons of dead plants and animals, corals, tiny sea animals as clams, oysters, and mussels which form great beds of calcium carbonate. Teacher educator may also give example of chalk which is a soft porous form of limestone made from the shells of tiny animals that lived millions of years ago. Sedimentary rocks often contain the remains of early animals and plants, called fossils, embedded in them. Soft coal is sedimentary rock formed from the remains of plants that died long ago and were then changed by heat and pressure into a rocky materials.

Teacher trainee/pupil activity : 3 Trainees are told to obtain samples of sedimentary rocks as limestone, sandstone, rock salt and shale. Teacher educator may help to examine these rocks carefully with and without magnifying glass. Point out how each of these rocks was formed.

Teacher trainee/pupil activity : 4 Trainees/pupils may observe how sediments settle in water to form layers. In a large glass jar trainee/pupil can add small stones, sand and fine earth or silt until the jar is filled one-third to one half. Add water until the jar is almost full, screw the cap on tightly, and then shake the jar and its contents. Put the jar down and allow the materials

to settle. Teacher educators will point out that the heavier, course materials will settle to the bottom first, and the lighter finer particles will form a layer on top.

iv) Teacher trainees/pupils will learn that metamorphic rocks, are igneous and sedimentary rocks that were changed by heat and pressure. Teacher educator will explain that metamorphic means "changed in form". Such changes are physical in nature, where original materials in rock were only rearranged. Other changes are chemical in nature, where new minerals were formed. Teacher educator will give examples of common metamorphic rocks such as slate, marble, hard coal, quartzite and gneiss. Teacher educators will have to explain further that quartzite is a very hard rock formed from sedimentary sandstone. Slate is a fine grained rock that splits very easily into thin sheets and it is formed from sedimentary shale. Marble is a large-crystal rock formed from sedimentary limestone. Gneiss is commonly formed from igneous granite. Hard coal is formed from soft coal which is a sedimentary rock. Hard coal is also changed by further heat and pressure to graphite, which is pure carbon now no longer useful as a fuel but useful for marking pencils and other purposes.

Teacher trainees/pupils activity : 5

Teacher educator may help the trainees/pupils to examine metamorphic rock. Ask them to obtain samples of metamorphic rocks such as slate, quartzite, marble, hard coal and gneiss. Trainees/pupils will observe with and without magnifying glass to determine composition of the rock. Discuss how these rocks were formed.

	Suggested Teaching Strategies
Major concept(s) Soil is the tiny grains of rock and minerals **Minor concept(s)** i) Nature of soil ii)Quality of the soil layer differs iii) Kinds of soil	iii) Teacher educator will explain how soil is formed, nature of soil quality of soil layers and different kinds of soil. Teacher educator will explain that the forces of mechanical and chemical weathering act on rock very slowly but these forces, over the millions of years have broken all the rock on or near the earth surface in a layer of tiny rock pieces and large boulders. This layer of pieces of rock is called mantle rock. The forces of weathering continue to act on this mantle rock until a layer of soil is formed. Soil is made up of tiny grains of rock and minerals. Soil becomes fertile when humus, the remains of dead animals and plants, is added to it. There is a difference in the quality of the soil layer. The first 20 centimeters (8 in) of soil is called the top soil or A-horizon. This layer of top soil is rich in humus. The top soil is fertile and it is the soil that helps crops grow. The soil underneath the top soil is called the sub soil or B.horizon. It has little or no humus in it but contains lot of pebbles in it. Beneath the subsoil is partly weathered bedrock (C-horizon), then solid bed rock. **Teacher trainee/pupil activity : 1** Teacher educator may help the teacher trainees/pupils to examine top soil and subsoil. Ask the trainees to collect a sample of top soil from a flower or vegetable bed. At the same time, let the trainees collect subsoil after having dug 50 centimeters (20 inch) into the earth. Help the trainees to compare both kinds of soil for quantities of humus and pebbles or stones. While keeping all other conditions same ask the trainees/pupils to plant a seed in top soil and in subsoil and observe which kind of soil produces the sturdier plant.

iii) Trainees/pupils will learn that soil contains different sizes and kinds of rocks and minerals. These different rocks and minerals usually include large pebbles or gravel, smaller particles of sand and tiny particles of clay. Soil is classified according to the predominant kind of material within it such as : sandy, clay and loam. (1) Sand soil has mostly sand on it, together with a little clay, and it contains almost no humus. It does not hold water very well, and the water drains off quickly. There are very few minerals in sandy soil that plants can use. ii) Clay soil has mostly clay in it, together with a little sand and humus. Clay soil holds water very well, and it dries very slowly. It is very sticky when wet, and it becomes almost as hard as rock when dry, iii) Loam is the soil that has proper amounts of gravel, sand and clay in it, together with lots of humus. It is usually dark-brown or even black in colour. Loam is the best soil for most crops.

Teacher trainees/pupils activity : 2 Teacher educator will help the trainees/pupils to compare kinds of soil. Teacher educator will ask the trainees/pupils to collect samples of gravel soil, clay soil, sandy soil and loam

soil. Trainees/pupils will examine small amounts of different kinds of soil carefully with and without magnifying glass. Point out that composition of each soil is different from other.

Teacher trainees/pupil activity : 3 Teacher educator will help the trainees/pupils to show how fast water goes into the soil. Ask the trainees/pupils to obtain a juice can and cut both ends. Push one end of the can ½ inch into the soil. Fill the cane with water and see how long it takes the can to become completely empty. Trainees/pupils will do this activity with sandy, clay and garden soils, packing all these three soils to the same consistency.

MATHEMATICS SECTION

1. CONCEPT OF REAL NUMBERS

Historical and Logical Development

The study of numbers starts with natural numbers {1,2,3,...} extends to fractions $\frac{5}{7}$, $\frac{+10}{211}$, $\frac{3}{4}$ ..., to rational numbers including integers and then to real numbers e.g. $\sqrt{2}$, $\sqrt[3]{-\frac{5}{4}}$, π and finally to complex numbers e.g. $7+2\sqrt{-1}$, $-3/4+\sqrt{7}$. $\sqrt{-1}$ etc.

These successively generalised kinds of numbers were historically developed in approximately the same order. Natural numbers have been used since time immemorial. Fractions were employed by the ancient Egyptians as early as 1700 B.C.; Pythagoreans in ancient Greece, about 400 B.C. discovered numbers, like $\sqrt{2}$ which cannot be fractions. The argument ran as follows: should $\sqrt{2}$ be a fraction p/q in its lowest form then $p^2=2q^2$ would imply that p is even; thus p^2 is divisible by 4, when the natural number q would also be even, contrary to the assumption that p/q is in its lowest form.

This discovery clashed with the philosophical and religious views to such an extent that it was dangerous to divulge it to the believers in God. Over the door of the Platonian Academy was inscribed "No admittance for those not proficient in Geometry". Not long before, Socrates had been sentenced to death for other 'novel practices'.

During the Middle Ages both rational and irrational numbers were employed without concern. The notion of zero and negative numbers as opposed to positive ones, was developed in India about the 6th Century A.D. The signs '+' and '–', however was being used only from the 1400 A.D. About the same time, the imaginary numbers e.g., $\sqrt{-1}$ started thrusting themselves into mathematics. The terms 'real' and 'imaginary' indicate that these concepts were not adopted without understanding. But even some rules for real numbers, like $(\lambda)(-1) = +1$ were considered mysterious.

The concept of a number was associated with the geometrical concept of a point and these two terms are still used as synonymous. Geometry, connected closely with the human organ of sight and its scanning ability, was more appealing than logical dedication. In many ancient books the proofs, even of arithmetical facts, were given by a geometrical picture with no verbal explanation. Diagrams are still helpful both in learning and teaching.

Thus, it seemed evident that the natural numbers correspond to a discrete sequence of points going in one direction of a straight time; the negative integers to their prologation to the other direction. The rational numbers correspond to points obtained by dividing intervals into smaller parts. The ancient Greeks knew, that this interpolation leaves out many points - in fact, all those corresponding to irrationals, like $\sqrt{2}$, $\sqrt{3}$. The number $\sqrt{2}$ was understood as the length of the diagonal of a unit square. It it is "evident" fact that the line is continuous motivated acceptance of the "existence" of real numbers. But the meaning of continuity itself was not explained, despite many attempts to do so. This was in striking and challenging contrast to the rigorous spirit of development of geometry, constructed axiomatically as early as 300 B.C. in Euclid's "Elements". The notion of continuity of real numbers, as well as the very concept of numbers were not separated from geometrical arguments until the nineteenth century, when it was based on more general foundations of the theory of sets and formal logic.

The deductive construction of various kinds of numbers imitates to a certain extent, their historical development. It starts with an axiomatic theory of natural numbers. Its first pattern was given in 1891 by G. Peano. Having constructed arithmetic of natural numbers, one can continue without additional axioms to generalise the concept of number, using only set theory and formal logic. An outline of that approach is given below.

In Peano arithmetic, natural numbers are considered elements of a set in which one assumes one primitive term the successor to a natural number without definition. The following anxious are also assumed without proof:

(1) Two natural number are equal if and only if their successor are equal

(2) There exists an element, denoted by 1, which is not a successor;

(3) The axiom of mathematical induction: If 1 belongs to a set K of natural

numbers and if $n \epsilon K$ implies that its successor also belongs to K, then every natural number belongs to the set K.

Mathematical Induction is logically equivalent to Well ordering axiom: Every non-empty subset S of natural numbers contains an element which is not a successor of any element of that set S. Another proposition logically equivalent with mathematical Induction is Dirichlet Box Principle:

If there are more apples than boxes and we put all the apples into the boxes, then in at least one box there will be more than one apple.

Dirichlet's Box Principle has to be stated in the language of arithmetic of natural numbers which does not use words like "apples" or "box". Then the equivalence can be proved formally with axioms in set theory. The arithmetic of natural numbers can be developed from the Peano axioms by defining new notions and proving theorems. The only tools used in this deduction are the Set theory and formal logic. Thus, for example, one defines addition (+), multiplication (X), the relation of "being smaller (<)", and one proves all the familiar rules. The chain of reasoning may be long but nevertheless it can be carried out as shown in.

An Introduction to Abstract Algebra by C.C. MacDufee (John Wiley).

The generalisation of natural numbers to integers, then to rationals, and then to real numbers, requires no additional primitive terms or axioms.

Construction of Integers from Natural Numbers

Integer numbers, among which substraction is always positive, can be constructed by the idea:

Let $N = \{1,2,3,....\}$ be the set of positive integers. We construct $N \times N$.

Then $N \times N = \{(a_1, a_2) / a_1, a_2 \epsilon N\}$.

We define a relation ρ in $N \times N$: $(a_1,a_2)\ \rho\ (b_1,b_2)$ holds if and only if

$$a_1+b_2 = a_2+b_1$$

Then to prove, ρ in an equivalence relation:

(i) $a_1+a_2 = a_2+a_1;\ a_1, a_2 \epsilon N \quad \Rightarrow (a_1, a_2)\rho\ (a_2, a_1)$ holds

$\Rightarrow \rho$ is reflexive

(ii) $a_1+b_2 = a_2+b_1 \quad \Rightarrow b_1+a_2 = b_2+a_1\ ;\ a_1, a_2, b_1, b_2 \epsilon N$

Hence $(a_1, a_2)\ \rho\ (b_1, b_2) \Rightarrow (b_1, b_2)\ \rho\ (a_1, a_2)$ holds. Thus ρ is symmetric.

(iii) $(a_1,a_2)\ \rho(b_1,b_2)$ and $(b_1,b_2)\ \rho\ (c_1,c_2)$ hold

The $a_1+b_2 = a_2+b_1$ and $b_1+c_2 = b_2+c_1$ where $a_1, a_2, b_1, b_2, c_1, c_2 \in N$.

But $a_1 + b_2 + c_1 = a_1 + b_1 + c_2$

Hence $a_2 + b_1 + c_1 = a_1 + b_1 + c_2$ by substition.

or that $(a_2+c_1) + b_1 = (a_1 + c_2) + b_1$ by associative and commutative property of addition in N.

Now cancelling b_1 on both sides,

$a_2 + c_1 = a_1 + c_2$ or that $(a_1, a_2)\ \rho\ (c_1, c_2)$ holds.

Hence ρ is transitive.

Thus the relation ρ is reflexive, symmetric and transitive and hence an equivalence relation. The equivalence relation ρ partitions the $N\times N$ into subsets of equivalent elements in $N\times N$.

If $a_1, a_2 \in N\times N$, then we name subset $\left\{(b_1,b_2) \mid \begin{matrix}(a_1,a_2)\rho(b_1,b_2)\\ or\ a_1+b_2=a_2+b_1\end{matrix}\right\}$ of $N\times N$ as a_1-a_2 or b_1 - b_2 etc.

Then $I = \{a_1 - a_2 \mid a_1, a_2 \in N\}$.

If $a_1 > a_2$ then a_1-a_2 is a positive integer.

If $a_1 < a_2$ then a_1-a_2 is a negative integer,

If $a_1 = a_2$ then a_1-a_2 is the integer 0.

Thus the set I contains all positive integers, O, and all negative integers.

Let A denote set of all those pairs $(a_1,a_2), (a_1',a_2'), (a_1'' a_2'')$ etc. which are equivalent with each other and B denotes another different set of pairs,

$(b_1,b_2), (b_1',b_2'), (b_1'',b_2'')$.. etc, which are equivalent with each other. We define A,B,... as the integer numbers. After this construction of integers we develop the arithmetic of integers afresh. This is done by an appropriate redefining of all counterparts known for natural numbers e.g. addition, A+B, multiplication, A×B, ordering A<B etc. and by defining new elements that do not have the counterparts among the natural numbers e.g. zero, negative integers. This program can be carried out as shown in

A survey of modern Algebra by G. Birkoff and S Mclame (Macmillan).

Construction of rationals from Integers:

From integers we pass to the rational numbers in a analogous to that by which the integers have been constructed from the natural numbers.

Consider the subset $\{(a,b) \mid a,b \epsilon I,\ b \neq 0\}$ of $I \times I = \{(a,b) \mid a,b \epsilon I\}$.

We define a relation ρ' in $\{(a,b) \mid a,b\ \epsilon I,\ b \pm 0\}$ by, $(a_1, b_1)\ \rho'(a_2, b_2)$ if and only if $a_1b_2 = a_2b_1$.

If $a_1 = 0$. Then $0b_2 = a_2b_1$ or $0 = a_2b_1$. But $b_1 \neq 0$ therefore $a_2 = 0$.

Also if $a_2 = 0$ then $a_1 = 0$.

So if $(a_1, b_1)\ \rho'\ (a_2, b_2)$ then $a_1 = 0$ iff $a_2 = 0$.

Now $(a_1, b_1)\ \rho'\ (a_1, b_1)$ holds implying ρ' to be reflexive.

Also let $(a_1, b_1)\ \rho'\ (a_2, b_2)$ hold. Then $a_1b_2 = a_2b_1$ or $a_{1b}1 = a_1b_2$

Thus $(a_2, b_2)\ \rho'\ (a_1, b_1)$ holds $\Rightarrow \rho'$ is symmetric.

Let $a_1, a_2, a_3\ \epsilon I$ all different from 0, and that

$(a_1, b_1)\ \rho'\ (a_2, b_2)$ and $(a_2, b_2)\ \rho'\ (a_3, b_3)$ hold.

Then $a_1b_2 = a_2b_1$ and $a_2b_3 = a_3b_2$.

This implies $(a_1b_2)\ (a_2b_3) = (a_2b_1)\ (a_3b_2)$

$(a_1b_3)\ (a_2b_2) = (a_3b_1)\ (a_2b_2)$

$(a_1b_3 - a_3b_1)\ (a_2\ b_2) = 0$ by the distribution property.

in I and by commutative and associative property of multiplication in I.

Now $a_2 \neq 0$, $b_2 \neq 0$ implies $a_2b_2 \neq 0$.

Therefore cancelling a_2b_2, we have $a_1b_3 - a_3b_1 = 0$

or $a_1b_3 = a_3b_1$, or that $(a_1, b_1)\ \rho'\ (a_3, b_3)$ hold.

Hence ρ' is Transitive relation.

Since ρ' is effective, symmetric and transitive relation, therefore ρ' is equivalence relation is $\{(a,b) \mid a,b \epsilon I,\ b \neq 0\}$.

Writting $\frac{a}{b}$ forall those elements (c,d) in $\{a,b) \mid a,b\ \epsilon I,\ b \pm 0\}$ such that

$(a,b)\ \rho'(c,d)$ holds and collecting all such elements $\frac{a}{b}, b \neq 0$, we form the set Q,

Then the set Q is called the set of all rational numbers.

Hence $Q = \left\{ \frac{a}{b} \mid a \epsilon I, b \epsilon I, b \neq 0 \right\}$

If b=1 Then $\frac{a}{b} = \frac{a}{1} = a$ where a ϵI

Thus every integer positive, negative or zero belong to Q.

An equivalence relation was defined on the set N×N to extend N to I. In an analogous manner the set I was extended to Q.

Let us consider two rational numbers $\frac{p}{q}$ and $\frac{p'}{q'}$ where p, q,p′, q′ are all integers, q≠0, q′≠0. Writing the rational numbers $\frac{p}{q}$ and $\frac{p'}{q'}$ as ordered pairs (p,q) and (p′,q′). Two such pairs are equivalent if p×q′=p′×q. Let α denote the set of all those pairs (p,q), (p′,q′), ...etc. which are equivalent to each other. Let β denote the set of all those pairs (s,t), (s′,t′),... etc. where s,t, s′,t′ are integers, t±0, t′±0, and that s×t′=s′×t i.e. (s,t), (s′,t′)... etc. which are equivalent to each other. We define $\alpha,\beta,\ldots$ as the rational numbers. Again, we have to develop the arithmetic of rational numbers by redefining all the counterparts known already for Integers and by defining new elements e.g., fractions which do not have their counterpart among the integers.

Construction of Reals from Rationls

The passage from rational number to the real numbers differs substantially from the two previously described transitions. Integers were defined by the use of pairs of natural numbers, rational numbers were defined by the use of pairs of integers. However, we can not pass from rational numbers to real numbers by using pairs of rational numbers or even sets of finite number of rationals. We have to use sets of infinitely many rational numbers to get a real number as done by G. Cantor. One method, worked out in 1872 was that given by R.Dedekind. He defines a Dedkind Cut by taking tabing two infinite subsets of rational numbers. Using Dedekined cuts, he defined the set of all real numbers. The method is two difficult and cumbersome. Between the rational and the real numbers, the algebraic numbers are constructed by use of only finite set of rationals. A number X is called albegraic of degree n, if it satisfies some equation of the form.

$a_0x^n + a_1x^{n-1} + \ldots + a_{n-1}x + a_n = 0$ with rational coefficients $a_0, a_1, a_2, \ldots, a_n$ and does not satisfy any other such equation of degree less than n.

All rational numbers are algebraic numbers of degree one. There are also many irrational numbers e.g. $\sqrt{2}$, $8\sqrt{7}$, $3\sqrt{5}+\sqrt{3/7}$, etc. which are algebraic. Thus the set of all algebraic numbers contains the set of all rational numbers as a subset. In 1851, J. LIOUVILLE proved that there are real numbers called transcendental which cannot be algebraic. Examples of transcendental numbers are e, π etc. Among algebraic numbers there are also some complex numbers. For instance $i=\sqrt{-1}$ is an algebraic number because it satisfies the equation $x^2+1=0$. A complex number is of the form $\alpha+i\beta$, α,β reals, $i=\sqrt{-1}$. There is continuity among complex number. This is evident from a geometrical point of view if the complex number are interpreted as points on a plane.

In the above development, called the deductive development of the concept of real numbers the only axiomatic theory used was that of Peano's arithmetic of natural numbers. The arithmetics of integers, rationals and real numbers were superstructures built up on Peano's arithmetic of natural numbers by means of set theory and formal logic.

Similarly we can assume axiomatically the arithmetic of integers (independent of Peano's arithmetic) but including the concept of natural numbers to construct the concept of rational numbers. Similar construction of real numbers can be made from each of the sets of integers or rational numbers using set theory and formal logic.

An axiomatic theory assumes certain primitive terms without definition and certain statements called axioms, without proof. Then than by use of set theory and formal logic, further concepts are defined and further statements, called theorems, are proved.

Axiomatic of Real Numbers

Real numbers α, β, γ, ... are elements of a set satisfying the following axioms, which are divided for further comments into groups marked by letters N, I, Q, R.

N. There are two operations in the set : Called + and $\cdot$

a) + and $\cdot$ satisfy closure property.

b) + and · satisfy associative property.

c) + and · satisfy commutative property.

d) There exists a unit element 1 in the set such that

$1.\alpha = \alpha.1 = \alpha$ for every α

e) There exist ordering relation $\leq$ between any pair of elements α and β. This relation is trichotomic, i.e., for every α and β, one only one of the relation holds:

$$\alpha < \beta,\ \alpha = \beta,\ \beta < \alpha$$

It is also transitive: i.e., if $\alpha < \beta$ and $\beta < \gamma$ then $\alpha < \gamma$.

Addition is monotonic : i.e., if $\alpha < \beta$ then $\alpha + \gamma < \beta + \gamma$ for every γ.

f) Multiplication is distributive with respect to addition;

i.e., $(\alpha + \beta)\gamma = \alpha\gamma + \beta\gamma$

I) a) There exists an element, O, with the property

$$\alpha + 0 = 0 + \alpha = \alpha \text{ for every } \alpha$$

b) There exists $-\alpha$ for every α. $-\alpha$ is called the negative of α such that $\alpha + (-\alpha) = 0 = (-\alpha) + \alpha$

c) Multiplication · is monotonic; i.e., if

$$\alpha < \beta \text{ and } \gamma > 0 \text{ then } \alpha\gamma < \beta\gamma.$$

Q) There exists for every $\alpha \neq 0$, its inverse, $\frac{1}{\alpha}$ such that $\alpha \cdot \frac{1}{\alpha} = 1$

R. Continuity of Real Numbers : For every set of real numbers bounded from above there exists a real number which is the least upper bound for that set.

In order to illustrate how the arithmetic of real number can be derived from these axioms, we shall prove some theorems and define some concepts.

1. The element 1 is unique. If there exists another unit element 1′ then

$1 \cdot 1' = 1'$ (taking 1 as a unit element)

$1 \cdot 1' = 1$ (taking 1′ as a unit element)

2. Cancellation law for addition : If $\alpha + \gamma = \beta + \gamma$ then

$$\alpha = \beta$$

If possible $\alpha \neq \beta$ then either $\alpha < \beta$ or $\beta < \alpha$

$\Rightarrow \alpha + \gamma < \beta + \gamma$ or $\beta + \gamma < \alpha + \gamma$

by monotony of + in R and trichotomy order relation

3. To prove that $0\alpha = 0 \forall \alpha$ in R :

$\beta\alpha + 0\alpha = (\beta+0)\,\alpha$ by distribution property

$= (\beta)\alpha = \beta\alpha + 0$ by property of 0. Now by cancellation law for addition in 2 above $0\,\alpha=0$.

4. To prove that $(-1)\alpha = -\alpha$:

$\alpha+(-\alpha) = 0$ existence of negative

$= 0\,\alpha$ by 3 above

$= (1+(-1))\alpha$ by existence of 1 and its negative

$= \alpha + (-1)\,\alpha$ by distributive law

$\therefore (-\alpha) = (-1)\,\alpha$ by 2 above, i.e, cancellation law.

5. To prove that $\alpha<\beta \Rightarrow -\beta < -\alpha$

Given $\alpha<\beta \Rightarrow \alpha+(-\alpha) + (-\beta) < \beta+(-\alpha)+ (-\beta)$

or $(-\beta) < -\alpha$

Using commutative addition and monotony property of addition.

so if $\alpha>0$ then $-\alpha<0$.

6. To prove $(-1)\,(-1) = 1$

$1 + (-1) = 0 = (-1).0 \quad = (-1)\,(1+(-1)) = (-1)1 + (-1)(-1)$

$= -1 + (-1)\,(-1)$

$= (-1)(-1) + (-1)$ by commutative property of+

$\therefore$ by cancellation and property of $3.1 = (-1)\,(-1)$

7. Cancellation low for multiplications : If $\alpha\,\gamma=\beta\gamma=$ and $\gamma\neq 0$ then $\alpha=\beta$

Now $\gamma\neq 0 \Rightarrow \frac{1}{\gamma}$ is a real number and that $\gamma \cdot \frac{1}{\gamma} = 1$

Let, $\alpha\gamma=\beta\gamma \;\; \gamma\neq 0 \Rightarrow (\alpha\,\gamma)\,\frac{1}{\gamma} = (\beta\gamma)\,\frac{1}{\gamma}$

$\alpha(\gamma \cdot \frac{1}{\gamma}) = \beta(\gamma.\frac{1}{\gamma})$ by associative property of multiplication

$\alpha=\beta.$

8. To prove that there are no divisors of zero : if $\alpha\beta=0$ then $\alpha=0$ or $\beta=0$

If possible let $\alpha\neq 0$, Then $\frac{1}{\alpha}$ exists

$$\alpha\beta = 0 \Rightarrow \frac{1}{\alpha}(\alpha\beta) = \frac{1}{\alpha}.0$$

$$\left(\frac{1}{\alpha}\alpha\right)\beta = 0$$

$$1\cdot.\beta = 0$$

Thus if $\alpha \neq 0$ then $\beta = 0$. Hence the result.

9. $|\alpha| = \alpha$ if $\alpha \geq 0$
$= -\alpha$ if $\alpha < 0$, $|\alpha| = |\alpha - 0|$ gives the distance of point α on the real line from the origin.

By definition $|\alpha| > 0$ if $\alpha \neq 0$

Also $|\alpha| = |\alpha - 0| < \beta \Rightarrow -\beta < \alpha < \beta$.

10. $\big|\, |\alpha| - |\beta| \,\big| \leq |\alpha \pm \beta| \leq |\alpha| + |\beta|$

11. Open interval $(\alpha, \gamma) = \{\beta \mid \alpha < \beta < \gamma\}$

Closed interval $[\alpha, \gamma] = \{\beta \mid \alpha \leq \beta \leq \gamma\}$

A real number β is between α and γ

i.e., $\alpha < \beta < \gamma$ or $\gamma < \beta < \alpha$

if and only if

$$|\alpha - \beta| + |\beta - \gamma| = |\alpha - \gamma|$$

12. Characteristic property of the least upper bound:

Let $\underline{\alpha}$ be the least upper bound of a nonempty bounded above subset A of the set of all real numbers. Then for any real number $\beta < \underline{\alpha}$ there exist in A an element α_1 such that $\beta < \alpha_1 < \underline{\alpha}$.

Least upper bound of non empty bounded above subset A is unique.

If $\underline{\alpha}'$ be another least upper bound of A then

$$\underline{\alpha} \neq \underline{\alpha}'$$

$$\therefore \underline{\alpha} < \alpha' \text{ or } \underline{\alpha}' < \underline{\alpha}$$

If $\underline{\alpha} < \underline{\alpha}'$ then there exists an element $a \epsilon A$ such that $\underline{\alpha} < a < \underline{\alpha}'$. This implies $\underline{\alpha} < a$, $a \epsilon A$.

Thus $\underline{\alpha}$ is not an upperbound of the set A which is a contradiction. Hence $\underline{\alpha}'$ does not exists as a least upperbound of A. Hence the result.

Similarly every non-empty subset of R which is bounded below has a unique greatest lower bound.

13. Natural numbers:

From the formal point of view we must now define which of the real numbers, as defined by the assumed axioms, are to be considered natural numbers. The idea is to distinguish among the real numbers a subset of elements which satisfy the Peano axioms.

The first axiom, that two elements are equal if and only if their successor are equal, is readily satisfied by all real numbers, if we call $\alpha+1$ as the successor of α. However, the other Pearno axioms are not satisfied in the whole set of real numbers. For instance, the axiom that 1 is not a successor is false, because 1 is a successor of 0 in the whole set of real numbers. Also, the other Peano axiom namely the Mathematical Induction, is not satisfied because the proposition that every element is positive is false in the whole set of real numbers. Hence, we shall define the class of natural numbers as the subset of real numbers of which 1 is not a successor and for which Mathematical induction holds.

These natural numbers as defined above, do not satisfy the axioms I and Q, but form a smallest subset of real numbers, satisfying the axiom N exclusively. In fact the axioms stated in N can be proved as theorems in Peano arithmetic.

14. Integers, rational numbers :

The integers can now be defined as the smallest subset of real numbers satisfying only the axioms N and I. Again the rational numbers are defined as the smallest set of real numbers satisfying only the axioms N, I and Q.

This arrangement of the axioms of real numbers initiates the historical development. It does not require formal change of the previously accepted axioms for the passage from naturals, then to integers, then to rational numbers and finally to real numbers. Each successive group I, Q, R of axioms requires the existence of some new element. In the axiomatic development of real numbers the axioms stipulating the ordering of N and the axiom of continuity in R play essential parts.

Let $C_m C_{m-1} C_{m-2} \ldots, C_1 C_0 \cdot d_i d_2 \ldots d_n$ (1) be a decimal expansion in which there is a finite number (m+1) of digits $C_m, C_{m-1} \ldots C_0$ before and a finite or infinite sequence of digits d_1, d_2.. after the point. We could also assume that there are always

infinitely many digits after the point by completing a finite sequence with infinite sequence of zeroes. Let all the digits in (1) be given. They represent a real number in the following way. Consider the number

$$C = C_m 10^m + C_{m-1}\, 10^{m-1} + \ldots + C_1 10 + C_0$$

and call it the integer part. Now consider the set of rational numbers

$$s_1 = \frac{d_1}{10}, s_2 = \frac{d_1}{10} + \frac{d_2}{10^2} \ldots, \quad s_n = \frac{d_1}{10} + \frac{d_2}{10^2} + \ldots \frac{d_n}{10^n},$$

$$= s_{n-1} + \frac{d_n}{10^n} \ldots, \tag{2}$$

$$0 \le s_n \le \frac{9}{10} + \frac{9}{10^2} + \ldots + \frac{9}{10^n} = \frac{9}{10}, \left\{\frac{1-\frac{1}{10^x}}{1-1/10}\right\} = \frac{9}{10} \times \frac{10}{9}\left\{1 - \frac{1}{10^x}\right\}$$

Thus every decimal expansion (1) represents a unique real number.

If the decimal part in (1) is finite then $\alpha = s_n$ for some n

However it is not true that every real number can be presented by a unique decimal sequence (1)

For example let $\Psi = .999999\ldots$

then $10\Psi = 9.99999\ldots$

$10\Psi - \Psi = 9$

$9\Psi = 9$ or $\Psi = 1$

Thus $\Psi = 1.0000 \ldots$ and $\Psi = .9999\ldots$

represent the same number.

So if we exclude decimal sequence (1) which ends with a series of 9's after the point then every real number can be represented by a unique decimal sequence (1), called the decimal expansion of the corresponding real number.

Theorem on Decimal Expansion :

Every real number $0 \le \alpha < 1$ has one and only one decimal expansion.

$$\alpha = .d_1 d_2 d_3 \ldots d_n \tag{1}$$

in which the digits $d_1, d_2, \ldots, d_n, \ldots$ are determined by the following algorithm: We use $[\Psi]$ is the greatest integer function $\le \Psi$.

Let $\rho_1 = \alpha$ then $d_1 = [10\,\rho_1]$, If $d_1 < 10\rho_1$ Put $\rho_2 = 10\,\rho_1 - d_1$ otherwise stop.

$d_2 = [10\,\rho_2]$. If $d_2 < 10\rho_2$. Then put $\rho_3 = 10\rho_2 - d_2$ otherwise stop.

and then process continues

$$\rho_1 = \alpha\ ,\ d_1 = [10\rho_1]\,,$$

$$\rho_2 = 10\rho_1 - d_1\,,$$

$$= 10\alpha - [10\alpha]$$

$$\rho_3 = 10\rho_2 - d_2$$

$$= 10^2\alpha - [10^2\alpha]$$

$$d_2 = [10\rho_2] = [10^2\rho_1 - 10d_1]$$

$$= 10^2\rho_1] - 10[10\rho_1]$$

$$d_3 = [10\{10^2\alpha - [10^2\alpha]\}]$$

$$= [10^3\alpha] - [10^2\alpha]\,.$$

$$\therefore \rho_{n+1} = 10\rho_n - d_n \quad \text{then}$$

$$d_{n+1} = [10\rho_{n+1}]$$

$$\therefore \rho_n = 10^{n-1}\,\alpha - [10^{n-1}\,\alpha]$$

$$d_n = [10^n\alpha] - 10[10^{n-1}\,\alpha]$$

This can be proved by induction. The algorithm is unique. Therefore $d_1, d_2, \ldots d_n$ are unique. Hence $\alpha = d_1 d_2 \ldots$ is the unique decimal expansion. Now the partial sums $\{s_n | n \in N\}$ satisfy the inequalities.

$$s_1 = \frac{d_1}{10}\,, s_2 = \frac{d_1}{10} + \frac{d_2}{10^2}\,, \ldots, s_n = \frac{d_1}{10} + \frac{d_2}{10^2} + \frac{d_n}{10^n}$$

$$= s_{n-1} + \frac{d_n}{10^n}$$

$$s_n \le s_{n+1}\ \ ;\ \ \alpha = \frac{d_1}{10} + \frac{d_2}{10^2} + \ldots + \frac{d_n}{10^n} + \ldots$$

$$\alpha - s_x \ge 0 \quad \alpha - s_n \ge \alpha - s_{n+1}\,.$$

$$0 \le \alpha - s_{n+1} \le \alpha - s_n = \frac{d_{n+1}}{10^{n+1}} + \frac{d_{n+2}}{10^{n+2}} + \ldots$$

$$\le \frac{9}{10^{n+1}} + \frac{9}{10^{n+2}} + \ldots$$

$$= \frac{9}{10^{n+1}} \left\{ 1 + \frac{9}{10} + \ldots \right\}$$

$$= \frac{9}{10^{n+1}} \left\{ \frac{1-(\frac{9}{10})}{\frac{9}{10}} \right\} = \frac{9}{10^{n+1}} \cdot \frac{10}{9}$$

$$\le \frac{1}{10^n}.$$

Theorem : A number is rational if and only if its decimal expansion is either finite or periodic.

We have seen that a finite or periodic decimal expansion is a rational number. Now let α be a rational number such that

$\alpha = \frac{a}{b}$ is its lowers terms, $b \geq 1$. is a positive integer.

Then by (2) in the last page

$$\rho_n = 10^n \alpha - [10^{n-1} \alpha]$$

$$= 10^n \cdot \frac{a}{b} - \left[10^{n-1} \frac{a}{b}\right]$$

$$b\rho_n = 10^n a - b\left[10^{n-1} \frac{a}{b}\right]$$

$\therefore b\rho_n$ is a positive integer for all $n \in N$.

This shows that $b\rho_n$ is an integer and it is greater than equal to 0 since $0 \le \rho_n < 1$

If $\rho_n = 0$ for some n the $b\rho_n = 0$ and the algorithm stops and the decimal expansion is finite.

$\therefore 0 < \rho_n < 1$.

If for every n $0 < \rho_n < 1$ then $0 < b\rho_n < b$

Thus $b\rho_n$ can be one of the natural numbers 1,2,3,..., b-1

The b integers

$b\rho_1, b\rho_2, b\rho_3, \ldots b\rho_b$ can have values belonging to the set $\{1,2,3,\ldots b_{-1}\}$

Hence for some K and K+p; K, p both positive integers $b\rho_K = b\rho_{K+p}$

Thus $\rho_K = \rho_{K+p}$.

The algorithm for digits them by induction implies

$\rho_{K+1} = \rho_{K+p+1}$ and so on

or that $\rho_{k+p} = \rho_{K+p+r}$

for any positive inter r.

By algorithm the same follows for the digits $d_{K+1} = d_{K+p+1}$ etc. i.e., $d_{k+r} = d_{K+p+r}$.

Thus the decimal expansion is periodic or recurring.

★ ★ ★

2. NUMBER SYSTEM

1. Almost what we do now depend directly or indirectly on the numbers. They are governing us all in one form or the other. The sheperd in earlier times used to keep a pebble in a stack in the morning when a sheep was allowed to go out from his farm yard for grazing. In the evening he used to make another stack by taking out one pebble from the earlier stack against a sheep entering the farm. This activity started the process of counting and also the relation of one-to-one correspondence. In our boyhood we were taught to count the balls by familiar names: one, two, three ..... etc. and wrote the numerals for them as 1,2,3,... etc. The number 1,2,3...., etc. are called the natural numbers. Whatever we say during the counting are the natural numbers and what we write for them are the numerals for the numbers. The first name we learn is one as it is the first natural number. It has a successor in the list, that is, the successor of 1 is 2. The successor of 2 is 3 and in general the successor of the counting or the natural number n is n+1. The predecessor of n+1 is n. The number 1 has no predecessor or that 1 is not the successor of any natural number. The counting can proceed without any end or interruption. So there is no last natural number. The set of natural numbers is denoted by N, where

$$N = \{1,2,3,4,6,7,....\}$$

2. In the set of natural numbers N there exists an element 1ϵ N such that $1.n = n.1 = n, \forall n$ and there does not exist a number say 0 in N such that

$$n + 0 = 0 + n = n, \forall n \epsilon N$$

We extend the set N to the set say

$$N^* = NU\{0\} = \{0,1,2,3,4,...\}$$

where $O \epsilon N^*$ and it satisfies

$$0 + n = n + 0 = n, \forall n \epsilon N^* \quad \text{(A)}$$

N^* is called the set of all whole numbers.

Also $O \epsilon N^*$ has the property.

$$0.n = n.0 = 0, \forall n \epsilon N^* \quad \text{(B)}$$

Besides the properties (A) and (B) all the properties which are satisfied by elements in N are also satisfied by elements in N^* obviously $N \subsetneq N^*$

3. We now extend the set of whole numbers N^* to the solution of Ψ of the equation.

$$\psi + n = m, \forall n, m \in N^*, n > m$$

or $$\psi = m - n, \forall n, m \in N^*, n > m$$

The equation $\Psi + 8 = 17$ has a solution 9 for Ψ.

But the eqn. $\Psi + 17 = 8$ has no solution in N^*

In N^*, n-m is possible when $n > m$ but m-n is not possible when $n > m$.

In order to accommodate the results $\forall m, n \in N^*$ we extend N^* to the set I of integers.

Thus $I = \{-3, -2, -1, 0, 1, 2, 3, ...\}$

Obviously $N \subsetneq N^* \subsetneq I$.

4. The operation of subtraction of a greater member of N^* from a smaller member of N^* caused the extension of N^* to the set I. Let us now think about the operation of division in I. We know $\pm\frac{72}{6} = \pm 12$ has a meaning in I but $\frac{72}{11}$ or $\frac{36}{5}$ have no meaning in I. $\frac{72}{11}$ or $\frac{36}{5}$ is very much undefined in I. To accommodate ratios of numbers in I, the set I is extended to another set

$$Q = \left\{ p/q \;\middle/\; \begin{matrix} p \in I \\ q \in I, q \neq 0 \end{matrix} \right\}.$$

Q is called the set of rational numbers. Any integer $l \in I$ can be represented as a rational number $\frac{l}{1}$ or $\frac{-l}{-1}$ or $\frac{2l}{2}$ or $\frac{-2l}{-2}$ etc. All the rationals generated by $\frac{l}{1}$ (or l) are

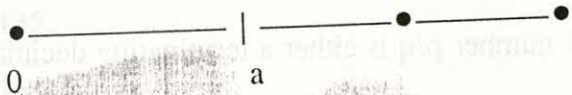
$$\frac{-l}{-1}, +\frac{2l}{2}, \frac{-2l}{-2}, \frac{3l}{3}, \frac{-3l}{-3} \text{ ..... etc. etc...} \qquad \text{(c)}$$

and they are equivalent to each other. So all fractions in (c) represent the same rational number $\frac{l}{1}$ or l. Thus $l = \frac{l}{1} \in Q$. In that sense $l = \frac{l}{1} \in Q$ and hence $I \subsetneq Q$.

Division by 0 is not defined. That is the reason for writing $q \in I$, $q \neq 0$ when representing a rational number $\frac{p}{q}$. Here p and q are the numerator and denominator respectively of $\frac{p}{q}$.

The rational number p/q can be positive (when both p and q have the same sign) or negative or zero.

5. Between two rational numbers a and b, $a<b$ there lies at least one rational number.



The rational number $\frac{a+b}{2}$ is such that $a<\frac{a+b}{2}<b$. Now taking the mid-point of a and $\frac{a+b}{2}$ we can find another rational number $\frac{a+\frac{a+b}{2}}{2}$ such that

$$a<\frac{a+\frac{a+b}{2}}{2}<\frac{a+b}{2}.$$

Hence there is an infinite number of rational numbers between a and b. This property is called the denseness property of rational numbers.

6. <u>Terminating Decimals</u> : A terminating decimal $\bullet a_1a_2..a_n$ is a rational number of the form p/q where

$p = a_1a_2 \ldots a_n$

$q = 10^n,\ 0 \le a_i \le 9 \quad i = 1,2, \ldots p.$

7. <u>Non-terminating recurring decimals</u> :

A non terminating recurring decimal number Ψ is of the type

$$a_1 a_2 \ldots a_p \cdot b_1 b_2 \ldots b_r \overline{c_1 c_2 c_3 \ldots c_n}$$

where $0 \le a_i, b_j, C_K \le 9$

$i = 1,2,\ldots p$

$j = 1,2,\ldots r$

$k = 1,2,\ldots n$

Then

$$10^{r+n}\psi = a_1a_2 \ldots a_p b_1 \ldots b_r c_1 c_2 \ldots c_n \cdot \overline{c_1 c_2 \ldots c_n}$$

$$10^r \psi = a_1 a_2 \ldots a_p b_1 b_2 b_r \cdot \overline{c_1 c_2 \ldots c_n}$$

$$10^{r+n}\psi - 10^r\psi = a_1a_2 \ldots a_p b_1 b_2 \ldots b_r c_1 c_2 \ldots c_n - a_1 a_2 a_p b_1 \ldots b_n$$

$$\psi = \frac{a_1a_2 - a_pb_1b_2 \ldots b_rc_1c_r \ldots c_n - a_1a_2 \ldots a_pb_1b_2 \ldots b_p}{10^r(10^n - 1)}$$

which is of the form $\frac{p}{q}, q \neq 0 \quad p, q \in I$

8. Every rational number p/q is either a terminating decimal such as $\frac{3}{4}, \frac{37}{25}$ etc.

or a non-terminating recurring decimal such as $\frac{1}{7} = 0.142857142857 \ldots\ldots$

9. <u>Decimal numbers</u> :

$(a_1 \ldots a_p \,.\, b_1b_2b_3 \ldots\ldots)$

- Terminating decimals $(a_1a_2 \ldots a_p.\ b_1b_2 \ldots b_n$
- Non-terminating decimals
  - $0 \leq a_i,\ b_j \leq 9$
    $i = 1, 2, \ldots p.$
    $j = 1, 2, 3, \ldots$
  - Non-terminating but recurring (repeating) decimal numbers
  - Non-terminating non-recurring (non-repeating) decimal numbers

Every rational number is either a terminating decimal or a non-terminating recurring (repeating) decimal numbers. A terminating decimal is a rational number. Also a non-terminating recurring decimal is a rational number as shown in 7.

Hence a non-terminating non-recurring decimal number is not a rational number of the form $\frac{p}{q}, p, q \in I,\ q \neq 0$. These non-terminating non-recurring decimal numbers are called irrational numbers. Example $\sqrt{2}, 3^{1/3}\ 17^{1/8}, e, \Pi$ are irrational numbers in the sense that none of them can be expressed in the form $\frac{p}{q}, p, q \in I,\ q \neq 0$ .. In other words a number which when expressed in decimal form which is neither a terminating decimal nor a non-terminating recurring decimal is an irrational number.

Thus every non-terminating non-recurring decimal is an irrational number.

Examples : 0.02002000200002 .... is a non-terminating non-recurring decimal.

Similarly 0.23233233323333 .....

0 13 113 1113 11113 ....., 0.404004000 are irrational numbers.

Each of

$\sqrt{2} = 1.4142135.....$

$\sqrt{3} = 1.73205.....$

$\sqrt[3]{5} = 1.709975947.....$

$\Pi = 3.1415926.....$

has non-terminating and non-repeating decimals. Thus each of them is an irrational number.

10. There are infinitely many irrational numbers between two rational numbers.

11. Between two irrational numbers A and B with A<B there lies atleast one irrational and hence an infinite number of irrational numbers.

Given two distinct positive rational numbers a and b such that ab is not a perfect square, then the irrational number $\sqrt{ab}$ lies between a and b. Let x and y be two rational numbers. We find two rational numbers and b such that

$x < a < b < y$

and ab is not a perfect square.

Now $x < a < \sqrt{ab} < b < y$.

Therefore $\sqrt{ab}$ is an irrational number between x and y.

12. Irrational numbers can be represented by points on the number line:

Corresponding to every irrational number there exists a unique point on the number line.

Let the number line be l. Let

a = 0.10 100 1000 100001 ..... be an irrational number. We have to find a point on the number line l which will correspond to the irrational number a.

I. We know 0.1 <a<0.2 and .1 and .2 are rational numbers.

Thus a lies in the closed interval d_1=[.1, .2]

II. Now 0.101 and 0.102 are also two rational number such that

0.101 < a < 0.102

This shows that a lies in the closed interval.

$$d_2 = [.101\,,.102] = \{r \text{ is a real number} \mid .101 \le r \le .102\}$$

We assume that $d_2 \subseteq d_1$

III. Again 0.101001 and 0.101002 are two rational numbers such that

$$.101001 < a < .101002$$

This shows that a lies in the closed interval

$$d_3 = [.101001\,,.101002] = \{r \text{ is a real number} \mid .101001 \le r \le r \le .101002\}$$

We observe that $d_3 \subseteq d_2 \subseteq d_1$

Proceeding in this way we can construct a sequence of closed intervals.

$$d_1\,, d_2\,, d_3\,, ...,d_n\,,.....n \in N$$

such that

$$d_1 \supseteq d_2 \supseteq d_3 \supseteq ....\supseteq d_n \supseteq d_{n+1} \supseteq .....$$

where each of the closed intervals d_n contains the number a in it. We can see that the length of each closed interval is decreasing and (length of $d_n=0$ as $n\to\infty$) intuitively see that length shrinks to a point P on the line. Since every closed interval contains the irrational number a and also the point P on line l therefore P represents the irrational number a=0.101001000100001.....

13. To find two rational number between the two given irrational numbers

A = 0.232332333.....

B = 0.21211211121111

Clearly B < A Let y = .23233

x = .23

$\therefore$ B < x < y < A.

Therefore between two irrational numbers there are infinite number of rational.

14. Find two irrational numbers between the two given rational number x,y, x < y.

Find the rational numbers a and b such that ab is not a perfect square and that $x < a < b < y$

Then $x < a < \sqrt{ab} < b < y$.

Then find a rational number c and that bc is not a perfect square and that

$x < a < \sqrt{ab} < b < c < y$. Then $x < a < \sqrt{ab} < b\sqrt{bc} < c < y$. The two irrational numbers are $\sqrt{ab}$ and $\sqrt{bc}$

15. Between any two rational numbers there are infinite number of irrational numbers.
16. Between any two rational numbers there are (infinite number) of both rational and irrational numbers.
17. Between any two irrational numbers there are infinite number of both rational and irrational numbers.
18. Rational numbers and irrational numbers taken together form the set of real numbers. This set is denoted by R. Thus every real number is either a rational number or an irrational number. Thus each real number has a decimal representation or expansion. A finite or a non-terminating recurring decimal number is a rational number while non-terminating non-recurring decimal is an irrational number.

    Thus we have

    $N \subsetneq N^* \subsetneq I \subsetneq Q \subsetneq R$

    In the system of real numbers $a^2 = (-a)(-a) = a.a. \geq 0$

    $\therefore a^2 = -1 < 0$ has no solution in the set R.
19. Complex number system :

    Let $C = \left\{ a + ib \mid \begin{matrix} a\, b \in R \\ i^2 = -1 \end{matrix} \right\}$

    If a=0 and b=1 then a+ib = 0+i.1 = i

    and $i^2=-1$. Therefore $i \notin R$.

    If we put b=0 then a+ib=a+io=aϵR

    In this sense complex number a+ib=a+i.O=aϵR.

    Thus $R \subsetneq C$:

    C has all the properties under addition and multiplication as per definition but has not ordering relation, viz.,

    a+ib < c+id or a+ib > c+id

    is not defined between two complex numbers. Except this ordering relation all properties in R are also in C. There is continuity among complex number. This is evident from a geometrical point of view if the complex numbers are interpreted as points in the plane.

3. PLACE-VALUE OF NUMBERS

Grouping by tens

We can write the numeral for any whole number with only the digits

0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

Observe the set 0,0,0,0,0,0,0,0,0 of say, balls. The word name for the number of elements is nine. The numeral for it is 9.

Let us add one more ball to the set above. Then the word name for the number of elements of the new set is ten. What will be the numeral for it? Can we use the digits.

0, 1, 2, 3, 4, 5, 6, 7, 8, 9

to write the numeral for ten or should we create another new symbol or new numeral for it? If we go on creating a new symbol or new numeral for each of the sets starting from the set containing ten objects and augment the sets by a single more object at each step then it will be difficult to remember each one of them. Already word name is different for each one of them.

So a plan has been devised. This ingenious plan has worked wonders and made the writing of numerals easy. Also their manipulation in arithmetic has become more systematic and scientific. The numeral for ten is written as 10 by using the digits 0 and 1. Mark that here we have two digits instead of one in earlier cases. This 10 stands for ten ones. The numeral for eleven is 11. The set has eleven balls, that is, one more than ten balls. So eleven means one 10 and one. This fact is recorded in the numeral 11. Logically this means 1 in the right most end of 11 stands for 1 (one ball) and 1 in the next place to the left some how denotes 10 (ten balls). Thus we see the same numeral 1 has different meanings. They have different values associated with them depending on its place of position in the numeral. The value described to a digit depending on its place in a given numeral is called its place-value. This logic as mentioned above was found consistent also and it really works.

In eleven 11 → Place value of 1 is one.
→ Place value of this 1 is ten.

Similarly in 12, place value of 1 is ten. and place value of 2 is one.
Therefore, 12 means there is 1 ten and 2 ones. Exactly because of it, the teaching is done in such a way that the numeral 17 means 1 ten and 7 one.

34 means 3 tens and 4 ones

89 means 8 tens and 9 ones.

Thus if one is tempted to assemble 10 (ten) ones into a group, then 17 will mean

1 group of ten and 7 ones, what in short, stand for 1 ten and 7 ones. A group of ten or 1 ten contains 10 ones (objects). Hence 17 also can be thought of seventeen ones.

Following the same representation

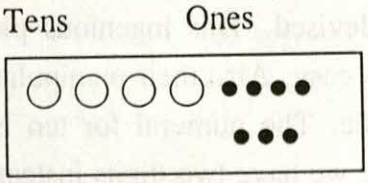
34 means

3 tens and 4 ones or thirtyfour ones.

8 tens and 9 ones or eighty nine ones.

Here are some examples to help you think about grouping by tens and ones in our working system.

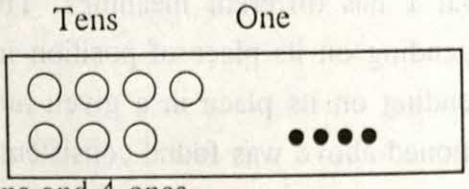
1(a)



4 tens and 7 ones

We write : 47

Word name : Forty seven



7 tens and 4 ones.

We write : 74

Word name : Seventy four

b) For both the numbers above we have used two digits 4 and 7. Both are 2-digit numbers.

c) In 47 the number four does not stand for four. It represents 4 tens while in 74 the number four stands for four ones. In 47, four (4) occupies the second place from right while in 74 it occupies the first place from right.

2.

We see	We think	We write	We say
	2 tens	20	Twenty
	3 tens	30	Thirty
	4 tens	40	Forty
	5 tens	50	Fifty
	6 tens	60	Sixty
	7 tens	70	Seventy
	8 tens	80	Eighty
	9 tens	90	Ninty
	10 tens	100	One hundred

Hundreds

10 represents what we call one ten or one ten and 0 ones or that ten ones.

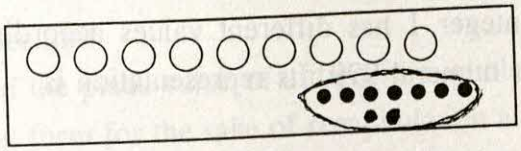
All the numerals under consideration at this stage have two digits. They are called two-digit or 2-digit numerals.

Let us consider Ninety nine. The numeral for it is 99.

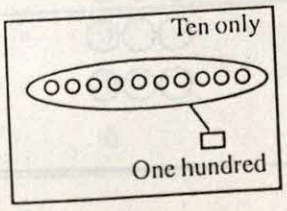
The representation of 99 is

as it has 9 tens and 9 ones. Add one more object to that of what we have above. The word name for the number is one hundred or simply hundred.

Now see that they can be grouped into tens and



no one lies outside the group and we have ten such groups.



One hundred can be represented by 10 tens and write the numeral as 100. They also represent 100 ones. Thus 10 tens and hundred (100) ones mean the same thing.

Pictorially one hundred objets will mean a rectangle as shown above.

3. In terms of place value we have learnt earlier 100 means, 10 tens and 0 ones. By counting the places from the right most end in the numeral 100 we find that one occupies the third place. We fix the place value of the third position from the extreme right end as hundreds.

   Thus 100 means 1 hundred 0 tens and 0 ones or 100 means 10 tens and 0 ones or 100 means 100 ones.

   Also one hundred means 1 will be followed by two zeros that is 100.

4. (a) Can you count one hundred pencils without counting higher than ten? Explain.

   (b) Can you draw one hundred fifty without counting higher than ten?

   (c) Can you draw one hundred twenty seven stars without counting higher than ten?

3-digit numerals

Consider the number one hundred eleven. The numeral for it is 111. Extending the same logic of representation from two-digit numerals. We have

Hundred	Ten	One
□	○	•

we write 111

The right most 1 in 111 stands for 1 ones. The 1 left to it in 111 occupies the second place which is the tens place. Therefore this 1 stands for 1 ten or 10.

The last 1 occupies the third place from the right most digit in the numeral. Its position puts the value 1 hundred to this 1.

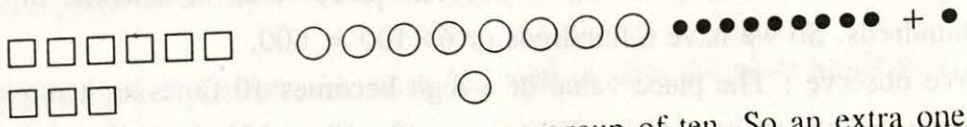
So the same integer 1 has different values according to its location in the numeral. Consider the numeral 999. Its representation is

9 Hundred	9 Tens	9 Ones
□□□	○○○	•••
□□□	○○○	•••
□□□	○○○	•••

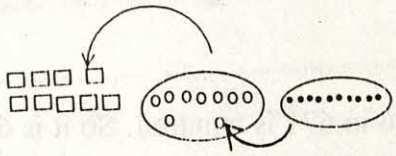
we write 999

999 is 9 hundreds 9 tens and 9 ones.

Add one more object to it.

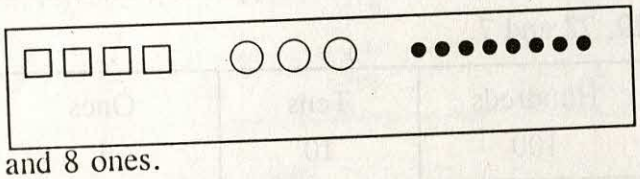


The last one has become ten ones. ten can put as a group of ten. So an extra one group of ten has been added to 9 tens to make it 10 tens or one hundred. Pictorially one gets.



9 hundred and extra one hundred.

This means we have 10 hundreds. We are accustomed to grouping in tens. Taking hundred as a group 10 hundreds will make a new grouping what we calla thousand. Thus we write 10 hundreds as 1000 (as 10 will be followed by two zeros). Therefore one thousand has 1000 as its numeral, 1 occupying the fourth places from the right most end.



4 hundreds 3 tens and 8 ones.

We write 438

We read the number as four hundred thirty eight.

(a) Number of ones is 8 and 8 occupies the right most place.

(b) Number of tens is 3 and 3 occupies the second place from the right end.

(c) Number of hundreds is 4 and 4 occupies the third place from the right end.

5. **Concept of a decimal**

We have studied the place-value of a digit in a whole number. Let us repeat it again in the following form for the sake of recapitulation and better understanding.

		Hundreds	Tens	Ones
Consider	386			
	965	100	10	1
	386	3	8	6
	965	9	6	5
and	671	6	7	1

The place value of the first numeral is ones. So we have 6 ones or $6 \times 1 = 6$.
The place value of 6 in the second numeral is tens.
So we have 6 tens or $6 \times 10 = 60$. The place value of 6 in the third numeral is hundreds. So we have 6 hundreds or $6 \times 100 = 600$.
We observe : The place value of a digit becomes 10 times as it moves from right most end to left by a place. It becomes $10 \times 10 = 100$ times if it moved from right most end to left by two places. And this process continues.

Let us see what happens when we move from left to right. Look to the same examples given above.

The place value of 6 in 671 is hundred. So it is $6 \times 100 = 600$. The place value of the digit 6 in 965 is tens. So it is 6 tens or $6 \times 10 = 60$, $= 600 \div 10$
The place value of 6 in 386 is ones. So it is $6 \times 1 = 6 = 60 \div 10$.

So we find that the place value of a digit is divided by 10 as it moves from the left to right by one place.

6. Consider another example of the same type. Let us study the place value chart for the numeral 729, 72 and 7.

Hundreds 100	Tens 10	Ones 1
7	2	9
	7	2
		7

The place value of the digit 7 in the first numeral is hundreds. It is $7 \times 100 = 700$. The place value of 7 in the second one is tens. Its value is $7 \times 10 = 70 = 700 \div 10$. The plave value of 7 in the third one is ones. Its value is $7 \times 1 = 7 = 70 \div 10$.

This again confirms our earlier observation that the place value of a digit is divided by 10 as the digit moves from left to right by one place. The place value of the digit is divided by $10 \times 10 = 100$ if it moves two places from left to right and so on.

7. At the next step can we push the digit 7 further by one more place to the right of the ones place ? I hope you will not mind as long as you have a pen in hand and a paper to write it on. Now what will be its place value?

8. Extending the same logic of movement from left to right the place value of 7 in this case should be $7 \div 10 = 7 \times \frac{1}{10}$. Writing $\frac{1}{10}$ as one tenth or what we call 7 tenths. The mathematicians found that this process works and is very consistent also. We extend and develop this idea by using the same example above.

	Hundreds 100	Tens 10	Ones 1	Tenths $\frac{1}{10}$	Hundredths $\frac{1}{10} \times \frac{1}{10} = \frac{1}{100}$
First	7	2	9	0	0
Second		7	2	0	0
Third			7	0	0
Fourth			0	7	0
Fifth			0	0	7

The place of the digit 7 in 729 is 700
in 72 is 70
in 7 is 7 ones
in Fourth one is $7 \times \frac{1}{10} = \frac{7}{10}$
or seven tenths.

The place of digit 7 in fifth one is $7 \times \frac{1}{100} = \frac{7}{100}$ or seven hundredths.

Now can we use a simple symbol to write seven-tenths ($\frac{7}{10}$) and seven hundredths (7/100) by using numerals which will be less cumbersome but will help in our work?

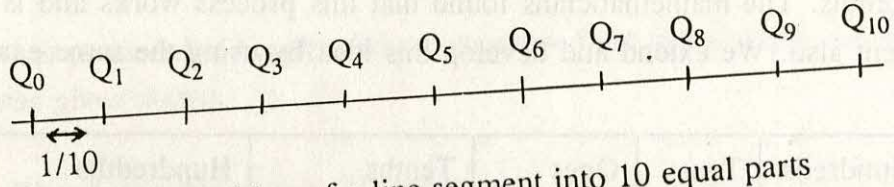
It is accepted that we can write seven-tenths or $7 \times \frac{1}{10} = \frac{7}{10}$ as .7

seven hundredths or $7 \times \frac{1}{100} = \frac{7}{100}$ as .07

just by filling the gaps by zeros in the given chart above. This representation of the fraction $\frac{7}{10}$ by .7

$\frac{7}{100}$ by .07

is called decimal representations. The decimal representation of the numerals in the above chart are 729.00, 72.00, 7.00, 0.70 and 0.07 respectively.

9. 

Division of a line segment into 10 equal parts

Pictures	Numbers (Word Name) one-tenth	Fractions	Decimals	Less than	Greater than
Q_0 Q_1	One-tenth	1/10	.1	.1 < .2	.2 > .1
Q_0 Q_2	Two-tenth	2/10	.2	.2 < .3	.3 > .2
Q_0 Q_3	Three-tenth	3/10	.3	.3 < .4	.4 > .3
Q_0 Q_4	Four-tenth	4/10	.4	.4 < .5	.5 < .4
Q_0 Q_5	Five-tenth	5/10	.5	.5 < .6	.6 < .5
Q_0 Q_6	Six-tenth	6/10	.6	.6 < .7	.7 < .6
Q_0 Q_7	seven-tenth	7/10	.7	.7 < .8	.8 > .7
Q_0 Q_8	Eight-tenth	8/10	.8	.8 < .9	.9 > .8
Q_0 Q_9	Nine-tenth	9/10	.9	.9 < 1.0	1.0 > .9
Q_0 Q_{10}	Ten tenths or one	$10 \times 1/10 = 10/10$	1.0		

4. SOME BASIC CONCEPTS IN ELEMENTARY GEOMETRY (EUCLIDEAN)

Minimum level of Learning (MLL) to be achieved:

The student should (1) draw the basic simple plane figures starting from points, lines, rays and angles (ii) see through some of the properties of these basic figures through drawing and practically discovering them by observations.

Competency to be Developed:

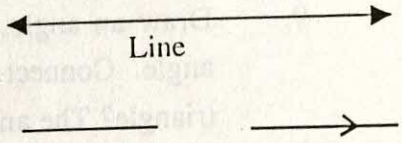
Drawing of plane figures like triangles, parallelogram, rectangle, square, rhombus and circle and studying their properties by observation.

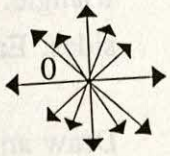
Competency Achievement Test:

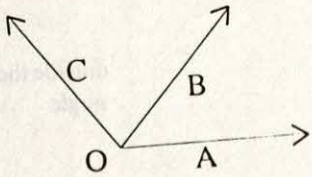
Equivalent test items are to be constructed on each concept and idea from the problems recorded and suggested.

Some figures of Geometry

Some basic figures of geometry are pictured at the right. Other figures of geometry are made up of these figures.





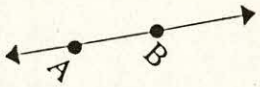


1. Mark a point 0 on your paper. Use your ruler to draw 6 different lines that pass through that point. How many lines can you draw?

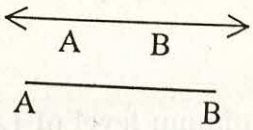
2. Mark a point 0 on your paper. Use your ruler to draw 4 different rays from that point. How many rays can you draw?

3. Mark two points on your paper. Use your ruler to draw the line that passes through these two points. How many lines can you draw through these two points?

4. Mark two points on your paper. Draw the line segment through these points. How many line segments can you draw?



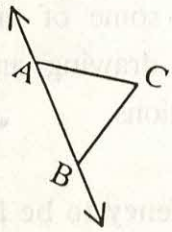
5. Draw the line segment AB through two points A and B on your paper. extend it on both direction to have the line AB. Take a point C not on AB.



a) Draw segments from C joining points on the line AB.

b) Draw line segments from C to A and B. What is the name of the figure you have drawn? How many segments did you draw?

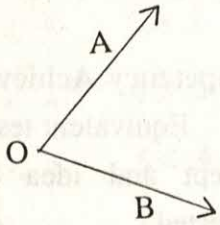
c) How may triangles you can draw in case of



(a) _____

(b) _____

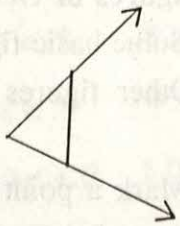
6. Mark one point 0 on your paper. Draw two rays from this point. The figure you have drawn shows an angle.



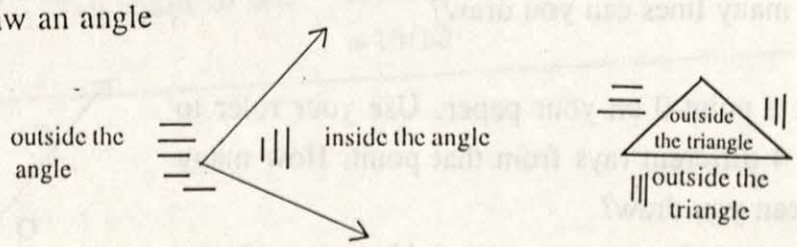
7. Draw a figure that is made up of 4 line segments.

8. Draw a figure that is made up of 5 line segments.

9. Draw an angle. Mark a point on each ray of the angle. Connect these two points. Do you see a triangle? The angle forms one of the corners of the triangle. Each triangle has 3 line segments called sides. Each triangle also has 3 .....



10. Draw an angle



11. Draw a triangle

12. Draw a triangle and mark a point inside the triangle put your pencil on the point and draw a path that crosses a side of the triangle.

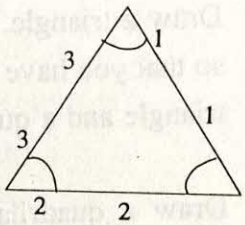
a) Where is your pencil point now, inside or outside?

b) Cross again. Where is your pencil point now?

c) If it crosses 7 times in all, where are you ?

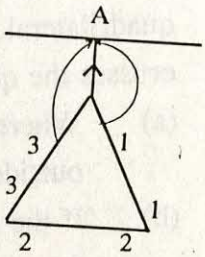
d) If it crosses 10 times in all, where are you?

13. Draw a triangle on a paper, colour each angle with different colours or mark, the sides as given by 1,2,3



a) Now cut out the triangle.

b) Draw a line on another paper. Mark a point on the line. Tear corners off your triangle. Then paste the corners around the point A like this. Make the edges touch, but do not over-leap.



14. make another triangle and use different colours to colour its corners or mark them by 4,5,6 as illustrated above. This time paste your 3 corners around the same point A above. put these corners on the other side of the line.

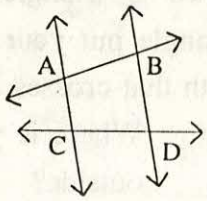
(a) Did the 6 corners go all the way around the point A.

(b) Do you think this would happen if you did it again with other triangles of different shapes ?

(c) What more you have observed ?

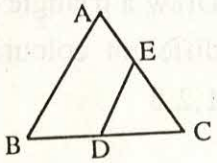
Quadrilaterals

15. Mark 4 points A,B,C,D on your paper. Make sure that no three of them are in a line. Now use your ruler to connect these points to form the four line segments $\overline{AB}$, $\overline{AC}$, $\overline{CD}$ and $\overline{BD}$. When you finish you get what we call a quadrilateral.



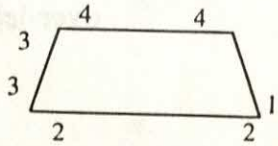
16. Draw one segment on your figure so that you have divided the quadrilateral into two triangles.

17. Draw a triangle. Draw one segment on this figure so that you have divided the triangle into a smaller triangle and a quadrilateral.



18. Draw a quadrilateral, Mark a point outside the quadrilateral. From this point, draw a path that crosses the quadrilateral 6 times.
    (a) Where will your pencil be then, inside or outside?
    (b) If the path crosses 13 times where will be your pencil, inside or outside?

19. Draw a quadrilateral. Colour each corner of the quadrilateral by different colours or mark its side as shown.

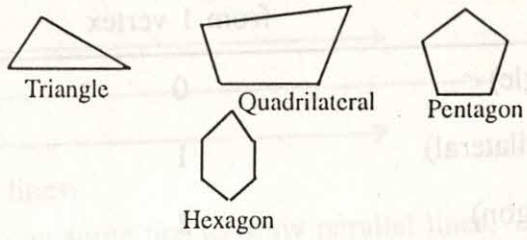


    a) Cut it out and tear off its corners.
    b) Mark a point A on another piece of paper. Paste the corners around the point A. Make the places touch but not over-lap. Do these corners go completely around the point?

20. Try this experiment with a quadrilateral of a different shape.

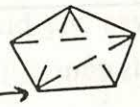
Polygons and Diagonals

21.



POLYGONS of 3 sides, 4 sides, 5 sides and six sides.

22. The dotted lines in the figure shows the diagonals of the polygon.



This point is one of he vertices of the Polygon. It is called a vertex of the polygon.

(a) How many diagonals does this polygon have ?

(b) How many diagonals are there from each vertex ?

23. Draw a 4-sided polygon (quadrilateral) on your paper.

(a) Draw all the diagonals.

(b) How many diagonals are there?

(c) How many are there from each vertex?

24. Draw a 6-sided polygon (hexagon) on your paper. Choose one vertex and call it A.

(a) How many diagonals can you draw from A ?

(b) Can you draw the same number of diagonals from each vertex?

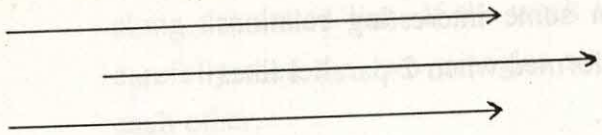
25.

Polygon	Number of diagonals from 1 vertex
3 sides (triangle)	0
4 sides (quadrilateral)	1
5-sides (Pentagon)	2
6-sides (Hexagon)	3
7-sides	

26. If a polygon has 10 sides, how many diagonals can you draw from each vertex?
27. How many diagonals can you draw from one vertex of a 15-sided polygon?
28. If one can draw just 10 diagonals from each vertex of a polygon then how many sides it will have ? How many vertices?
29. There are 15 diagonals from each vertex of a polygon. Find the number of its sides and also the number of its vertices.
30.

	Polygon	Total number of diagonals of the Polygon
	Triangle (3-sides)	0
	Quadrilateral (4-sided)	2
	Pentagon	5
	Hexagon	
	8-sided	
	9-sided	

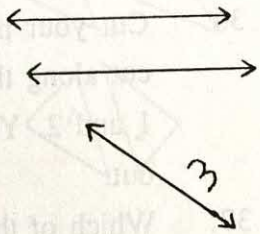
Parallel Lines



Parallel lines.

We are giving you some tips to draw parallel lines.

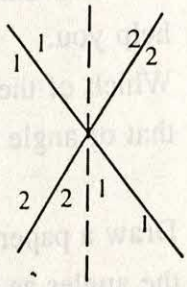
31. You can draw a pair of parallel lines by drawing on each side of your ruler.



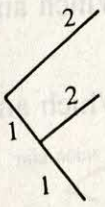
   (a) Draw some parallel lines using this method.

   (b) Would you say that line m in the picture is parallel to the lines drawn by the rulers.

32. Here is a way to get parallel lines by folding a paper. Follow the directions as demonstrated. Open your paper and use the folds to draw parallel lines. Try to find other ways of getting parallel lines by folding the paper.



33. Here is a way to use angles to get parallel lines.



   (a) Draw two lines on a paper that cross each other

   (b) Colour the inside of one angle red or mark it by 1,2.

   (c) Cut your paper as shown by dotted lines.

   (d) Cut out the angle you coloured that is along the lines 1 and 2.

   (e) Place the angle 1,2 or coloured one along one side of the other angle. Do you see some parallel lines?

   (f) Draw several different lines that are parallel to one side of the angle.

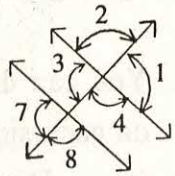
   (g) Try to discover a different way of placing the angle to get parallel lines.

34. Tell what you think parallel lines are

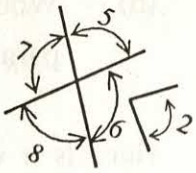
Angles and parallel lines

Here you will learn some interesting relations between the 8 angles formed when 2 parallel lines are cut by a third line.

35. Draw 2 parallel lines. Draw a third line that cuts the 2 parallel lines. Number the angles as in the figure.

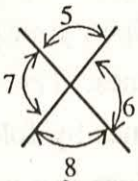


36. Cut your paper along the top parallel line. Then cut along the third line which contains the angles 1 and 2. You have now angle 1 and angle 2 cut out.



37. Which of the other angles (3,4,5,6,7 or 8) are of the same size as angle 2? Use cut out angle 2 to help you.

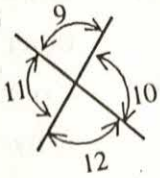
38. Which of the other angles are of the same size as that of angle 1? Use angle 1 cut out to help you.



39. Draw a paper of lines that cross each other. Letter the angles as 9,10,11,12 as in the figure.

(a) Which angle is of the same size as that of the angle 9?

(b) Which angle is of the same size as that of the angle 10?



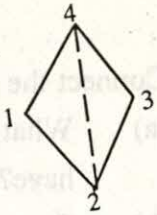
Parallelograms

In the last lesson we have learnt how to draw parallel lines. To draw a parallelogram we need to draw two sets of parallel lines that intersect.

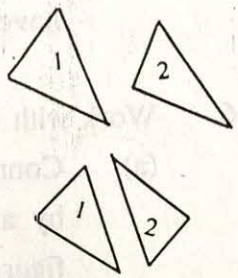
40. Draw two pairs of parallel lines that cross each other.

(a) Colour the inside of the parallelogram or mark its vertices by 1,23,4 as shown. Cut it out.

(b) Use your ruler to connect one pair of opposite corners, say 2 and 4. Then cut along the dotted line. If the work is done carefully then the two triangles should fit each other.



41. Draw a triangle on a paper.
Place another sheet of paper over the triangle and trace it carefully. We get two triangles say 1 and 2.



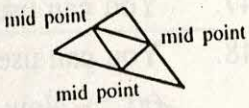
(a) Colour the inside of the triangles 1 and 2. Cut them out.

(b) Observe that they are exactly the same except for the colour or the marks 1 and 2.

(c) Paste one of the triangles on another sheet of paper. Now try to paste the other triangle next to the first one (pasted so that the two triangles together form a parallelogram.

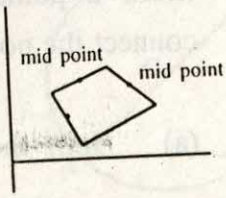
42. You can use folding to find the midpoint of the line segment or the side of a polygon. Take a sheet of paper and find the mid point of the edge by folding as demonstrated.

43. Draw a triangle and take a cut out. Find the mid point of two sides. Draw a segment to connect these mid points. How does this new segment related to the remaining side of the triangle?

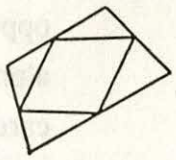


(a) Trace out the line segment joining the mid-points of two sides and the remaining side of the triangle on another sheet of paper. Then comment.

44. Draw a large 4-sided polygon on your paper
(a) Cut it out.
(b) Find the mid point of each side by folding.

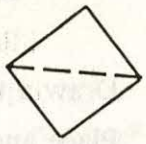


45. Connect the mid points by segments as indicated.



(a) What kind of a figure do you think you have?

(b) Cut out along the dotted lines and this may help you out.



(c) Do you think this would work if you would have started with a different 4-sided figure?

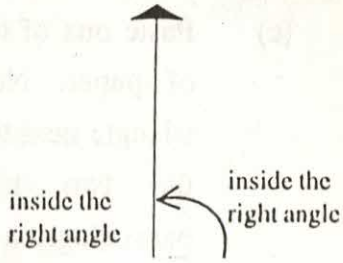
46. Work with the cut out obtained in 45 (b)

(a) Connect the opposite vertices in this cut out by a segment. This is a diagonal of the figure.

(b) Cut it out along the diagonal (dotted lines). You get two triangles.

(c) These two triangles fit each other.

(d) Therefore you have a parallelogram.



<u>Right angles</u>

You can draw a right angle in many ways.

47. You can use the corner of a book.

48. You can use two folds in a paper as demonstrated.

(a) Now open your paper and find a right angle.

Trace over one of the right angles with your pencil. Use the corner of a book to see that you have a right angle.

49. Mark 2 points on a paper. Use your ruler to connect the points.

(a) Join the two points by a line segment.

Make a cut along the segment.

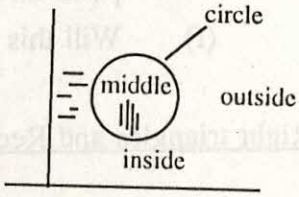
(b) Make another fold as shown.

(c) Now open the paper and find a right angle. Trace over the right angle with your pencil. Use a corner of your book to see that you have a right angle.

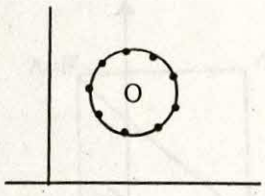
50. A rhombus is a parallelogram that has all four sides equal in length. You can draw a rhombus by first drawing two lines on both sides of your ruler. Then change the direction of the ruler in any way you like. Again draw two lines on both sides of the ruler in the changed position. You have now got a rhombus. Then draw the diagonals. Find a right angle.

Circles and right angles

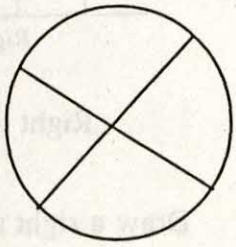
51. Now you will learn some interesting facts about circles. You will learn how to draw a right angle by using a circle.



52. Mark a point 0 on your paper. Mark many other points on the paper that are 5 cm from the point 0. Mark enough points so you can connect them to help you draw a circle.



53. Draw 5 circles using a round object such as cup, lid of a jar and a rupee coin.

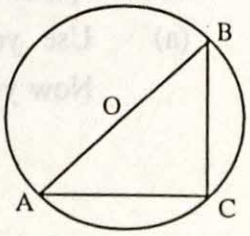


54. Draw a circle and cut it out.

(a) Fold your circle in half

(b) Again fold it in half making a second crease.

(c) Open the circle and paste it on a clean sheet



of paper.

(d) Draw the lines along the folds.

(e) These lines (along the creases) cross each other at a point.

(f) What point do you think this is?

55. Draw over one of he creases having the centre marked.

(a) Mark the end points on this line segment by A and B.

(b) Take any point C on the circle different from A and B.

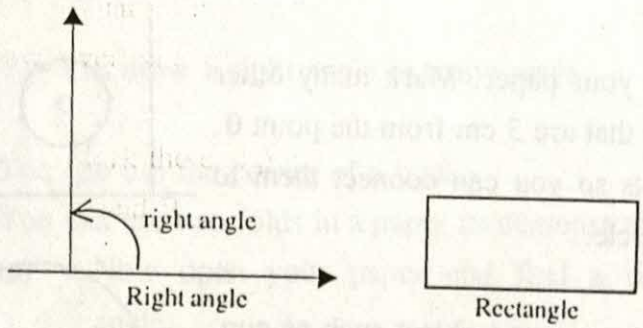
(c) Use your ruler to draw the line segments AC and CB.

(d) Find the right angle. Use a corner of your book to see.

(e) Repeat this again by choosing a different point on the circle.

(f) Will this always give you a right angle?

Right triangles and Rectangles

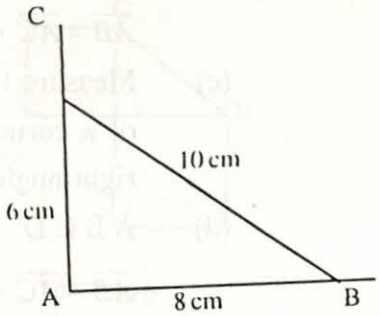


Right triangle Rectangle

56. Draw a right angle on your paper.
Mark a point on each ray of the angle.

(a) Use your ruler to connect these points. Now you will have right triangle.

57. Draw a right angle on your paper. Make the sides at least 10 cms long.



(a) On one side mark the point C, 6 cms from the corner A. On the other side mark the point B 8 cms. from the corner A.

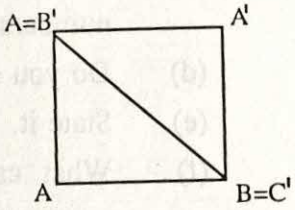
(b) Connect these two points B and C and measure this segment. If your work is good thence $\overline{BC}$ should be 10 cms long.

(c) Cut it out. It is the right triangle ABC.

(d) Take the cut out and trace it out on another sheet of paper. Take the cut out from the tracing.

(e) Let us call this right triangle A′B′C′. Put the first cut out ABC on a sheet of paper. Fit in the second cut out A′B′C′ on the first cut out ABC. Such that A′ is on A, B′ is on B, C′ is on C.

(f) Now flip around A′B′C′ in such a way that B′ falls on C,C′ on B and A′ moves in the opposite direction to A as indicated in the figure.



(g) Angle at A and angle at A′ is a right angle.

(h) In the figure ACA′B measure the angle ACA′ and ABA′ by using a corner of your book.

(i) Observe angles ACA′ and ABA′ are right angles.

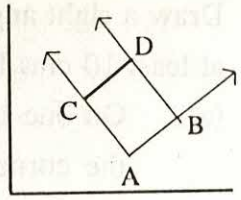
(j) Hence ACA′B is a rectangle.

(k) Will ACA′B give you a parallelogram?

58. Draw a right angle A on your paper.

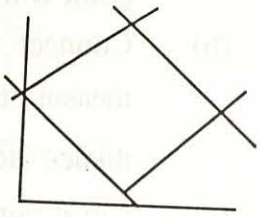
(a) Use a wide ruler or carefully fold the paper to draw lines as shown.

(b) Measure $\overline{AB}$. Mark points C,D such that $\overline{AB} = \overline{AC} = \overline{CD} = \overline{BD}$



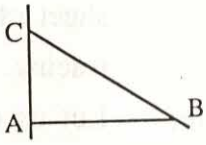
(c) Measure the angles at B.C.D with the help of a corner of your book. See they are all right angles.

(d) ABCD is a rectangle with $\overline{AB} = \overline{AC} = \overline{CD} = \overline{BD}$



(e) This special rectangle is called a square.

59. Draw a right triangle on a paper.



(a) Colour inside the two angles that are not right angles. Colour them with different colours. Or mark them by 1,23 as indicated in the figure.

(b) Cut out the triangle. Tear off the two corners or angles which are not right angles.

(c) Take a new sheet of paper. Draw a line on it. Fix a point on it. Paste the right angle at this fixed point. Fit in the other two corners over the right angle by matching the side numbers. Do your work carefully?

(d) Do you see something interesting?

(e) State it.

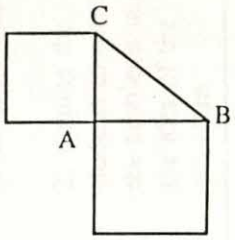
(f) What can you guess about the sum of measures of three angles in a right triangle?

60. Fold your paper as shown to draw a right angle.

(a) Unfold the paper. Draw 2 segments AB and AC of the same length (say 5 cms) with a pencil. The segment BC is opposite to the right angle.

(b) Draw squares, one on each side AB and AC as shown. Make sure that length of each side of the square on AC remains

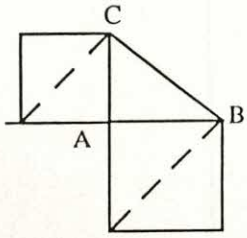
same. Measure the angles of the square to see that each angle is a right angle.



(c) Draw the diagonal lines as shown.

(d) Colour the four parts of the squares by different colours.

(e) Cut out the whole figure. Cut out each of the four coloured pieces. Keeping the triangle ABC in tact.



(f) Figure out how to fit the four pieces together to form a square on $\overline{BC}$. Each square you form should have the same length as $\overline{BC}$.

(g) After you have figured out how to form the square on $\overline{BC}$ complete your work by pasting the triangle ABC and the four pieces on a new sheet of paper.

61. Try the same experiment when $\overline{AB} = \overline{AC}$ and $\overline{CB}$ is 10 cm.

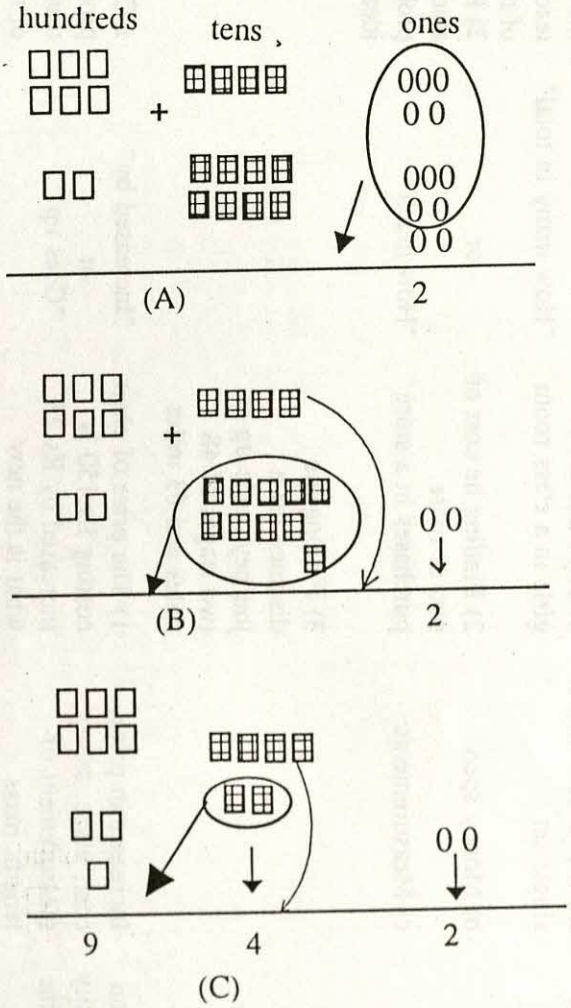
(a) Do you think the squares on $\overline{AB}$ and $\overline{AC}$ could be made to fit in the square on $\overline{BC}$?

5. ADDITION

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET ADDITION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
AGGREGATION	Refers to a situation where two or more quantities are combined into a single total	a) Putting the objects from two sets into a single set b) Money spent c) Measurements	1) Combining the set of boys and set of girls in a class room 2) Finding he cost of two or more purchases in a store 3) Finding the distance for a journey made up at two stages of 48 miles and 63 miles	"How many in total" or "How much"	1) Construction of the problems by the teacher using the idea of the structure 2) Helping the students to construct problems using the idea of the structure
AUGMENTATION	Refers to a situation where given quantity is increased by some amount. The operation of addition is used to find the augmented or increased value	Increases in price, cost, wage, salary, measurement of length, mass	1) The price of chair costing Rs.150 is increased by Rs.25 what is the new price?	"Increased by" or "Goes up"	1)Construction of the problems by the teacher using the idea of the structures. 2) Helping the students to construct the problems using the idea of the structure

Process for addition calculation

To add : 6 4 5
+ 2 9 7



In A all the ones make 12 ones. 12 ones are then put into a group of ten and 2 ones. The group of 10 ones makes one ten and this one group is carried over to the ten's place. As there is just one group of ten we carry one in the group of tens from the units place. In the units place there are only 2 units left.

In B there are 13 tens and the extra 1 ten from the right end make 14 tens altogether. We divide 14 tens into one group of ten tens and an extra of 4 tens are left. The one group of ten tens makes one hundred. So 1 is allowed to shift to the hundreds place. This shifting of 1 or carrying over 1 to the hundred's place stands for one group of ten tens. This leaves only 4 tens at the tens place in the addition process.

In C, we have to combine the hundreds. First we had 6 and 2. One group of ten tens is 1 hundred. We shift this one group ten tens to the hundreds place. As it is carried over it becomes 1 in the hundreds place. So in total we have 6+2+1=9 hundreds.

so 6 4 5
\+ 2 9 7
———————
9 4 2

2. **Adhoc methods of doing addition calculations**

i) 489 + 99

We increase 99 by 1 to 100 and at the sametime decrease 489 by 1 to 488.

Therefore 489+99 = 100 +488 = 588

ii) 507 + 374 507 = 500 + 7 = 500+6+1 = 800+80+1=881

(500+7) + (300+74) 374 = 300 + 74 = 300+74

iii) 369 300 + 50 + 19 300 + 50 + 10 + 9

\+ 572 500 + 50 + 22 500 + 50 + 20 + 3

800 + 100 + 41 = 941 800 + 100 + 30 + 11 = 941

This breaking up into hundreds, fiftys, tens and ones helps to add them easily on a paper. This can even be tried mentally.

These informal methods mentally or on paper lead to greater confidence of the children with the numbers.

Teaching points

a) Important languages used : hundreds, tens and ones.
Ten of ones can be exchanged for 1 tens
Ten of tens can be exchanged for 1 hundred after the exchange 1 carried over to the next place when we do addition calculation from the right most end.

b) Understanding of children can be developed by building of ten in a block of ones, tens, hundreds and showing them over and over again and to initiating them to use the blocks for addition calculations

c) To develop the association of language used with the addition of operations.

d) Adhoc informal methods of doing addition calculations be attempted to instill confidence in children with numbers.

6. SUBTRACTION

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET SUBTRACTION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
1. The Partitioning structure	Refers to a situation in which a quantity is portioned off.	a) If from a set with given number of things, a subset with a given number of things is taken away or removed	1) 17 dolls are in a box from which 5 are removed.	" Taken away" or "How many are left"	1) Construction of the problems by the teacher using the idea of the structure
		b) A finite set is given. The objects of the set have different characteristics, abilities or qualities.	2) 92 students went on a field trip, 48 of them belong to class III. How many of them do not belong to Class III?		2) Helping the students to construct the problems using the idea of the structure.
		c) money and shopping			
		d) Measurements given from a given length of some material cut off a length of it			

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET SUBTRACTION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
2. The reduction structure	a)Refers to a situation in which a quantity is reduced by some amount	Realistic examples at this structure mainly occur in the context of money. Key idea is "reducing"	Finding expenses reduced by Rs.200 from Rs.2000	"Reduced by" or "goes down by"	1) Construction of the problems by the teacher using the idea of the structure
	b) This lies behind the idea of counting back along a number line				2) Helping the students to construct the problems by using the idea of the structure.
3. Comparison structure	It refers to situation of comparing the number of elements/objects in two given groups and deciding how many more or less in one group than another	a) When two numbers of items of two sets are compared to determine which set has more or has less.	1) Class I has 18 students class II has 22 students. How many more students are there in Class II than Class I	"How many more" or "How many less" or "How much more" or "How much less" or	1) Construction of problems by the teacher using the idea of structure 2) Helping the students to construct the problems by
		b) Money : Comparing the prices of articles.	2) Ram's height is 165 cm. Rahim's height is 170 cm. By how much quantity Rahim is taller than Ram.	"How much greater" or "How much smaller"	using the idea of the "structure"

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET SUBTRACTION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
		c) Measurements: Comparing the heights of two children and deciding who is taller among the two			
4. Inverse of Addition	Refers to situations where we have to determine what must be added to a given quantity in order to reach a given target. To solve a problem of the form "what must be added to X to get Y?"	If there is given a number of objects and we require some more objects of the same side to reach a fixed target	Our cricket team has scored 225 in 40 overs. They have to score 272 to win. How many more runs are to be scored by our team in the remaining 10 overs to win the game?	"How much more is needed" or "How many more is needed" or "What must be added"	1) Construction of problems by the teacher using the idea of the structure 2) Helping to students to construct the problems by using the idea of the structure.

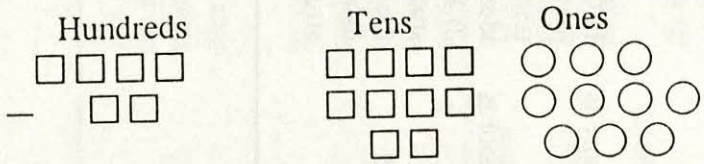
Process for subtraction Calculations:

Subtraction calculations can be done by:

a) the decomposition method

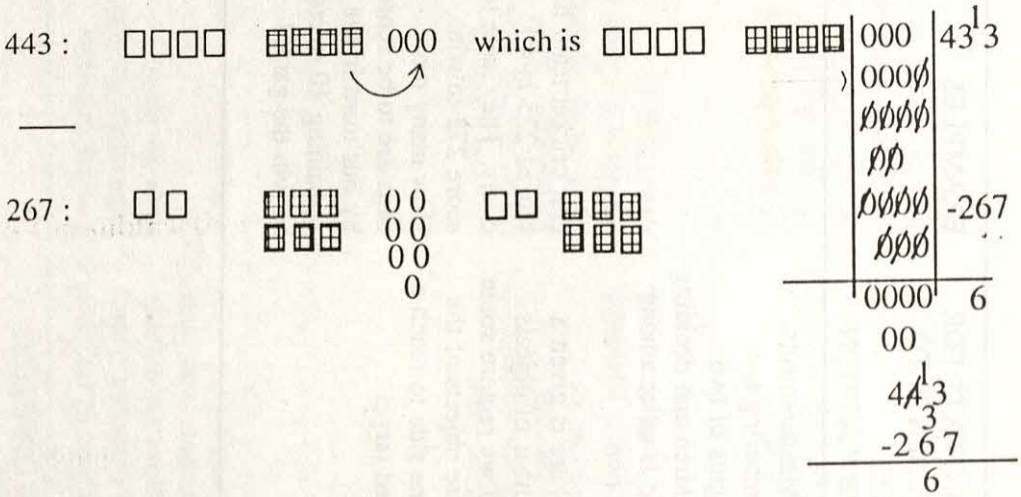
b) the equal additions method

To solve '443-267' by the decomposition method with base - ten blocks

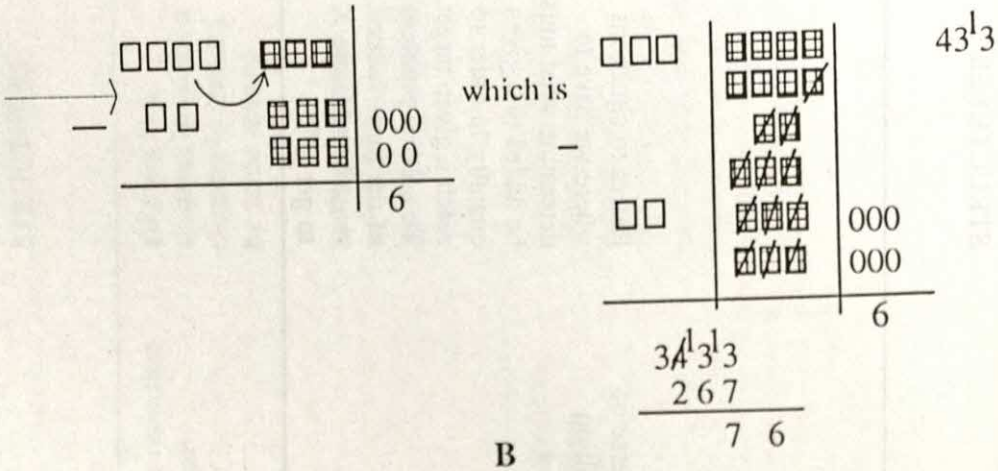


The task is to take 267 away from 443. In terms of base - ten blocks the task is to remove 2 hundred, 6 tens and 7 units from 4 hundred, 4 tens and 3 ones.

The standard algorithm works from right to left. We have to remove 7 units from 3 units which we cannot do easily. So we take one of the tens and exchange it for tens units.



A



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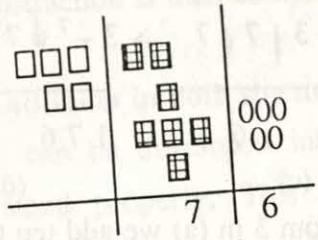


$$\begin{array}{r} 3^{1}\,3^{13} \\ 2\,6\,7 \\ \hline 1\,7\,6 \end{array}$$

C

In (A) 3 units in the top line is less than 7 units in the bottom line. So from 4 tens in the top line one ten has been shifted to the right thus making it 13 ones instead of 3 ones. One can remove 7 units from 13 units leaving only 6 units. But now there are 3 tens int he top line. At the right we have shown $44_3{}^{1}3$ in the top line from which to subtract 267. In (B), in the top line we have 3 tens which is less than 6 tens in the bottom line. We shifted 1 hundred to the tens position in the top line to make 13 tens in these. From 13 tens we can remove 6 tens leaving 7 tens.

At righ right $\begin{array}{r} 3\cancel{4}^{1}\cancel{4}_{3}^{1}3 \\ -2\,6\,7 \end{array}$

In (C) by removing 2 hundreds from 3 hundreds we are left with 1 hundred only.

$$\begin{array}{r} 3^{1}\,3\,{}^{1}3 \\ -\;2\;6\;7 \\ \hline 1\;7\;6 \end{array}$$

If one starts to work from left to right then process may be as follows :

Take away 267 from 443.

Can be broken up as

take away 200 from 443 leaving 243

take away 60 from 243 leaving 183

take away 6 from 183 leaving 176

This method gives calculation mentally if numbers are small.

The equal addition method

This method is based on comparison structure of subtraction. It uses the principle that the difference between two numbers remains the same if you add the same number to each of the top and bottom lines. The difference between heights of two persons remain the same if they stand on the same table instead of the

floor. For the last example '443-267'

```
 443  →  4 4 ¹3        4 ¹4 ¹3      4 ¹4 ¹3
- 267    2 ~~6~~ 7 7 →   3 ~~4~~ 7 ~~6~~ 7 →  3 ₇ ⁷~~6~~ 7
 ———     ———————         ———————      ———————
                  6          6        1 7 6
(a)      (b)            (c)              (d)
```

Unable to deal with take away 7 from 3 in (a) we add ten to both the lines. In the top line this ten is added to the units digit making it 13 instead of 3. This is indicated by writing 1 infront of 3. In the bottom line the ten is added in the tens column increasing 6 in it earlier to 7 now. This is shown as striking through 6 and writing 7.

In (b) we work with numerals in the tens place. We cannot take away 7 from 4 in the tens place. We add 1 hundred in both the lines. In the top line instead 1 hundred ten tens are added to make it 14 tens. In the bottom line we add this 1 hundred in the hundreds place to increase its present value 2 to 3. This is shown in (C). Now we are able to complete the subtraction as shown in (d)

Problems with zero in the top line during subtraction calculations

The decomposition method is the best method for subtraction. But there is a slight problem in using the decomposition method when there is a zero in the top number.

Decomposition method when there is a zero in the top number.

Let us calculate '802-247'

```
 802        ⁷8 ¹0 2      ⁷8 10 ⁹12        7 9 ¹2
- 247  →   -   2 4 7 →  -   2 4 7   →  -   2 4 7
 ———        ———————      ———————         ———————
                                            555
 (a)        (b)          (c)              (d)
```

In this subtraction shown in (a) we cannot take away 7 from 2. So by the decomposition method we bring 1 ten to the units place. But there are no tens in the tens. This is the problem. As there are no tens we go across to the hundreds column and exchange 1 hundred for 10 tens thereby reducing 8 to 7 in the hundred place while increasing 0 in the tens place to 10. This is shown in (b). From this 10 tens in (b) we exchange 1 ten to the units making 12 units from the original

2. But at the same time 10 tens is reduced to 9 tens in the tens place. This is shown in (c). The substraction is then completed in (d).

Idea of equal addition in both the numbers in subtraction calculations:

This method can be developed into an algorithm for a much easier calculation if understood properly. This process will help to calculate the difference mentally.

For the same example '443 - 267'

$$\begin{array}{r} 443 \\ -\ 267 \\ \hline \end{array} \rightarrow \begin{array}{r} 446 \\ -\ 270 \\ \hline \end{array} \rightarrow \begin{array}{r} 476 \\ -\ 300 \\ \hline 176 \end{array}$$

For the problem : '819 - 634'

$$\begin{array}{r} 819 \\ -\ 634 \\ \hline \end{array} \rightarrow \begin{array}{r} 815 \\ -\ 630 \\ \hline \end{array} \rightarrow \begin{array}{r} 800 \\ -\ 615 \\ \hline \end{array} \rightarrow \begin{array}{r} 785 \\ -\ 600 \\ \hline 185 \end{array}$$

The number in the bottom line into a round number of tens or hundreds by adding (or subtract) the same thing to both the number is the key to the solution to problem of subtraction.

Teaching points

1. Method of decomposition is the best method.
2. Understanding of the process is to be encouraged and instilled in a child but not the process without any meaning.
3. Instead of borrowing and carrying emphasis is to be laid on exchanging in the decomposition method.
4. Encourage the students to do a lot of problems giving themselves plenty of room for their crossings out and writing of 1s.
5. Discuss with students the principle of adding the same number (subtracting the same number) to both the numbers, can convert a subtraction question into an easier calculation.

7. MULTIPLICATION

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET MULTIPLICATION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
1. REPEATED AGGREGATION (extension of aggregation structure of addition)	i. Refers to the idea that multiplication means 'so many sets of' or 'so many lots of'. If one has 5 sets of 3 counters' then the questions, 'how many counters altogether' is allocated with the multiplication '3×5' ii. Refers to find the cost of number of items given the unit cost.	Any situation in which we aggregate a certain number of portions of a given quantity, such as mass, liquid volume, length and time. Shopping where one has to find the cost of items given the unit cost.	1) Finding the total mileage for 42 journey of 38 miles each. 2) Finding the total volume of drink required to fill 32 glasses if each holds 225 ml. 3) Finding the cost of 25 cans of drink at 39P each	"How many altogether"	1) Construction of the problems by the Teacher using the idea of the structure 2) Helping the students to construct the problems using the idea of the structure
2. SCALING (extension of augmentation structure of addition)	Refers to addition as meaning that we increase a quantity by a certain amount. So multiplication by 5 would be interpreted in this structure as scaling a quantity by a factor of 5. Also,multiplication by a number less than 1 would correspond to a	It is associated with scale models and scale drawings	1) If a scale model is built using a scale factor of '1 to 10', then each linear measurement in the actual object is 10 times the corresponding measurement in the model.	'Increase' or decrease' 'doubling' or 'trebling'	1) Construction of problems by teacher using the idea of the structure 2) Helping the students to construct the problems using the idea of the structure.

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET MULTIPLICATION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
	scaling which reduces the size of the quantity not increases it.		2) Ram earns Rs. 125 per day but his brother earns three times as much how much does his broken earns.	'so many times bigger' or 'so many times smaller	

Process for Multiplication Calculations:

Multiplication calculation can be made by:

a) The method of the long multiplication algorithm.

b) A simple method for multiplication using areas of rectangles

1. To calculate '26×34' by the method of long multiplication algorithm.

```
   26
 × 34
 ----
  780 ←———— This is 26 × 30
  104 ←———— This is 26 × 4
 ----
  884 ←———— This is 26 × 34
```

This method is based on the distributive law i.e. for any three numbers A,B,C.

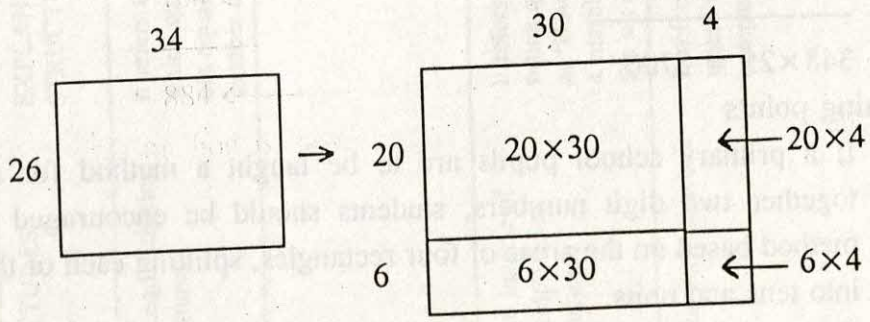
$$A \times (B+C) = (A \times B) + (A \times C)$$

Applying this principle to '26×34', we can think of it as '26× (30+4)' and get the answer by multiplying the 26 first by the 30 and then by the 4, and then adding up the results. This method is difficult one.

2. **To calculate '26×34' by using a simple method.**

This method is based on the idea of splitting up both the numbers being mutiplied into their tens and units. So 26 becomes '20+6' and the 34 becomes '30+4'. Then we have to multiply the 20 by the 30, the 20 by the 4, the 6 by the 30, and the 6 by the 4.

'26×34' can be explained very simply using the following diagrams



The answer to the multiplication is then obtained by working out the areas of the four separate rectangles and adding them up.

The actual calculation can be written out as:

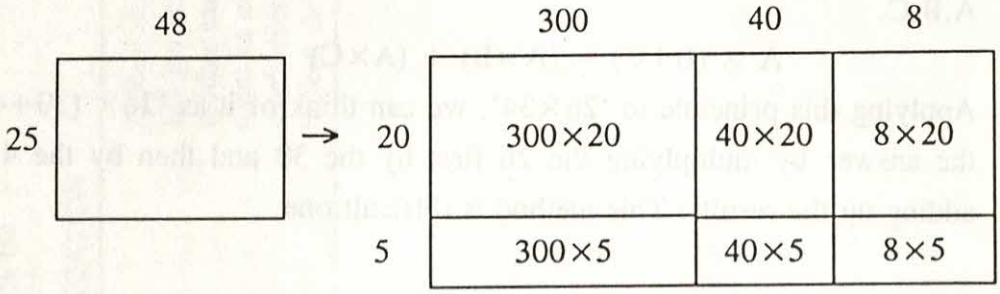
$$20 \times 30 = 600$$
$$6 \times 30 = 180$$
$$20 \times 4 = 80$$
$$6 \times 4 = 24$$

so $26 \times 34 = 884$

3. To calculate '348×25' using this simple method.

Splitting the 348 as 300 + 40 + 8 and 25 as 20+5 into their hundreds, tens, ones and tens and ones respectively, we multiply the 300 by the 20, the 300 by the 5, the 40 by the 20, the 40 by the 5, the 8 by the 20 and 8 by the 5. Then all the results are added.

'348 × 25' can be explained by using the diagrams.



The actual calculation can be written as:

$$300 \times 20 = 6000$$
$$40 \times 20 = 800$$
$$8 \times 20 = 160$$
$$300 \times 5 = 1500$$
$$40 \times 5 = 200$$
$$8 \times 5 = 40$$

so $348 \times 25 = 8700$

Teaching points

1) If a primary school pupils are to be taught a method for multiplying together two digit numbers, students should be encouraged to use the method based on the areas of four rectangles, splitting each of the numbers into tens and units.

2) The students should be encouraged to use the method based on the area of rectangles to calculate the multiplication of 3 digit number with two digit number.

8. DIVISION

STRUCTURES	EXPLANATION OF STRUCTURES	CONTEXTS FOR STUDENTS TO MEET DIVISION	EXAMPLES	KEY LANGUAGES	TEACHING POINTS
1. The equal-sharing structures	It refers to a situation in which quantity is shared out equally into a given number of portions	Sharing sweets, sharing pencils, sharing books and so on.	1) 20 marbles might be shared equally between 21 pupils in a game	"Sharing equally between"	1) Construction of problems by the teacher using the idea of the structure
		Measuring a given quantity into equal portions	2) Sharing of 12 marbles equally between 3 people 3) cutting up a 750 cm length of wood into 6 equal lengths		2) Helping the students to construct the problems using the idea of the structure
2. The inverse of multiplication structures	It refers to a situation in which question is asked as 'How many groups of 4 marbles are there in the set of 20 marbles	Situations in which a set is to be sorted out into subsets of a given size	A school with 240 students may wish to organise them into classes of 30 children	"How many" or "How much"	Construction at problems by the teacher using the idea of the structure
3. The ratio structure	It refers to situations where we use division to compare two quantities	comparing two numbers, comparing sums of money, comparing measurements of same kind.	Comparing two children's Journeys to school of 10 minutes and 30 minutes	"Bigger them" or "Smaller than" or "More than" or "Taller than"	Construction of the problem by the teacher using the idea of the structure

Process of Division Calculations

Division calculation can be made by:

(a) the adhoc repeated subtraction method,

(b) a number of informal, adhoc approaches.

To calculate '648 ÷24 by the adhoc repeated substraction method

This method uses the inverse of multiplication structure and the idea of the repeated subtraction. Hence the questions is: How many 24S make 648? We approach this step by step.

	(a)		(b)		(c)		(d)
10	648÷24		648÷24		648÷24		648÷24
	240	10	240	10	240	10	240
	408		408		408		408
		10	240	10	240	10	240
			168		168		168
				2	48	2	48
					120		120
						2	48
						2	72
							48
						1	24
							24
						27	0

Anser is 27

In (a): Ten 24s make 240; we subtract 240 from 648 which leaves us with 408 to find.

In (b): Try another ten 24s which makes 240. Subtract 240 from 408 leaving 168. We do not have enough for ten 24s.

So In (c), we try two 24s which makes 48. Subtract 48 from 168 leaving 120. We proceed in the same way, until we have used up all the 648 as in (d). Totting up

the numbers of 24s we have used down the left hand side gives us the answer to the calculation:

$10+10+2+2+2+1 = 27$ (Answer)

To calculate $648 \div 24$ by the other informal, ad hoc approaches:

Here we use the principle that the answer to a division calculation remains some if we divide both the numbers by the same thing.

$648 \div 24$ (dividing both numbers by 2) $324 \div 12$
$324 \div 12$ (dividing both number by 3) $108 \div 4$
$108 \div 4$ (dividing both numbers by 2) $54 \div 2$
$54 \div 2$ (dividing both number by 2) $27 \div 1 = 27$ (Answer)

Teaching points

1. Students should be taught the adhoc repeated substraction method for dividing first by single digit numbers and then by two-digit numbers.
2. Students should be taught the other informal, adhoc approaches to various division questions.

9. MULTIPLES AND FACTORS

Teacher Trainees students should be taught to use some properties of numbers, including multiples and factors.

Explanations of multiples :

1. **Concept of Multiples :** The multiples of any number are obtained by multiplying the number in turn by each of the natural numbers 1,2,3,4,5,6 and so on.

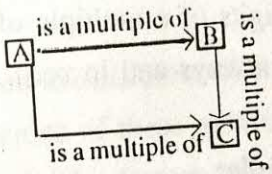
For example:

a) Multiples of 2 are : 2,4,6,8,10,12,14,16,.....

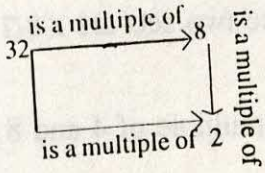
b) Multiples of 6 are : 6,12,18,24,30,36,42,48,.....

c) Multiples of 7 are : 7,14,21,28,35,42,49,56,..... etc.

2. **Transitive property of Multiples :** If A is the multiple of B and B is the multiple of C then A is the multiples of C. i.e.



For example, 32 which is a multiple of 8, must also be multiple of 2, because 8 itself is a multiple 72. i.e.



3. **Digital sum of a number :** The digital sum of a given number is a number obtained by adding the digits in the given number. For example digital sum of 234 is 2+3+4=9.

4. **Digital root :** The digital root is a single digit number which is obtained by a continuous process of adding the digits in the digital sum of a given number.

For example, the digital sum of the 2466 is 2+4+6+6=18 digital sum of 18 is 1+8=9

Thus 9 is the digital root.

5. **Some useful tricks for spotting various multiples**

a) Every natural numbers is a multiple of 1.

b) Multiples of 2 are even numbers and end in 0,2,4,6 or 8.

c) The digital sum of a multiple of 3 is always a multiple of 3; and the digital root is always 3,6,9.

d) The last two digits of a multiple of 4 are themselves a multiple of 4.

e) Multiples of 5 always end in 0 or 5.

f) Multiples of 6 are multiples of 2 and multiples of 3; so they must end in 0,2,4,6 or 8 and have a digital root of 3,6,9.

g) The last three digits of a multiple of 8 must be multiple of 8.

h) Multiples of 10 always and in zero.

6. **Lowest common multiple:**

Let there be two numbers and each number has a set of its multiples. Then the smallest number, common to both the sets of multiples, is known as lowest common multiple at the given two numbers.

For example : multiples of 4 are : 4,8,12,16,20,24,28,32,.....

multiples of 8 are ; 8,16,24,32,40,48,56,64,.....

The number common to the two sets are : 8,16,24,32,.....

The smallest of these is 8.

Thus, the lowest common multiple of 4 and 8 is 8.

This concept occurs in a number of practical situations. For examples: if Ram has to feed one plant every 4 days and another plant every 8 days, then the lowest common multiple indicates the first day on which both plants have to be fed, i.e., the 8th day,

Explanations of factors:

1. Concept of factors : The concept of factors is simply the reverse of multiple. For example, 16 is a multiple of 4, so 4 is factor of 16. We say "4 goes into 16". So the factors of 16 are all those natural numbers by which 16 can be divided exactly: 1,2,4,8,16. Of course, 1 is the factor of all numbers and every number is a factor of itself.

2.(i) The Rectangular arrays showing the factors of 16

X X X X X X X X X X X X X X X X

1 by 16

X X X X X X X X

X X X X X X X X

2 by 8

X X X X

X X X X

X X X X

X X X X

4 by 4.

The above figure shows all the different of rectangular arrays possible with a set of 16 crosses. The dimensions of these arrays are all the factors of 16: i.e. 1 and 16, 2 and 8, 4 and 4 i.e. 4. The factors of 16 are 1,2,4,8,16.

2(ii) The Rectangular arrays showing the factors of 28 :

X X X X X X X X X X X X X X X X X X X X X X X X X X X X X X

1 by 28

X X X X X X X X X X X X X X

X X X X X X X X X X X X X X

2 by 14

X X X X X X X

X X X X X X X

X X X X X X X

X X X X X X X

4 by 7

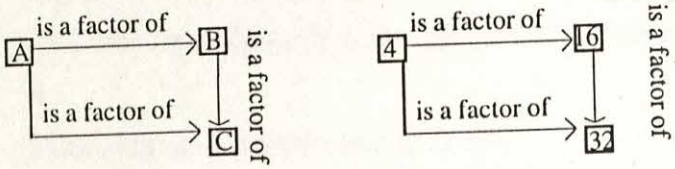
This above figure shows all the different rectangular arrays possible with a set of 28 crosses. The dimensions of these arrays are all the factors of 28: i.e. 1 and 28,

2 and 14, 4 and 7.

To determine whether or not a number is a factor of a given numbers:

The given number is divided by the possible factor if the answer is a whole number it is a factor, otherwise it is not. For example, 23 is a factor of 1955 because $1955 \div 23 = 85$ (whole number). And 15 is not a factors of 1955 because $1955 \div 15 = 130.33333$ (not a whole number).

3. Transitive property of factors : If A is factor of B and B is a factor of C then A is a factor of C.



Thus, any factor of 16 must be a factor 32, because 16 is a factor of 32.

4. Highest common factor:

Let there be two numbers and all the factors of these numbers be listed in two respective sets. Then the largest of the common factors of these two sets is known as the highest common factor of the given numbers. For example the two sets of fractors of 16 and 20 are :

Factors of 16 : 1,2,4,8,16

Factors of 20 : 1,2,4,5,10,20

The factors in common are 1,2,4. So the highest common factor of 16 and 20 is 4.

The concept of highest common factor can be illustrated with a rectangular array. The problem is to arrange 16 crosses and 20 noughts in a rectangular array. With the same combination of crosses and noughts in each row. The highest common factor of 16 and 20 is 4. Thus, 4, is the greatest number of rows possible. Hence, 16 crosses and 20 noughts can be arranged in 4 rows with 4 crosses and 5 noughts in each row as:

X X X X 0 0 0 0 0
X X X X 0 0 0 0 0
X X X X 0 0 0 0 0
X X X X 0 0 0 0 0

Teaching points :

1) Students should be helped in responding to numerical situations by exploring the concepts and properties of multiples and factors.

2) Teacher should share with the students some of the ways of testing of various multiples.

3) Rectangular arrays to illustrate the concepts of factors should be used.

★ ★ ★

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David Hare Training College,
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700019

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700019

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